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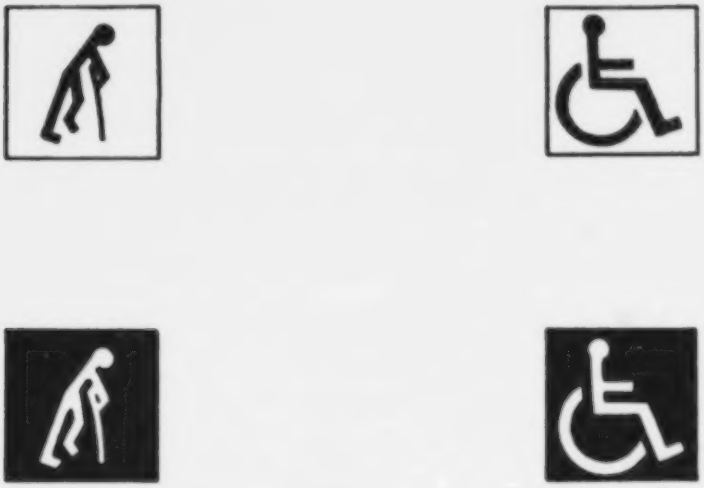
PEDESTRIAN CROSSWALK SYSTEMS FOR THE ELDERLY AND THE HANDICAPPED



FINAL REPORT
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PEDESTRIAN CROSSWALK SYSTEMS FOR THE ELDERLY AND THE HANDICAPPED

FINAL REPORT

by

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MANOP SERVICES LTD.

1007 Frederick Road
North Vancouver, B.C.
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December, 1984

0032

The contents of this report reflect the views of the Contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada. Where references are not quoted, the statements in the report reflect the experience of the project team.

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17. Abstract

This report provides an overview of: the needs of the elderly and the handicapped when travelling as pedestrians; the urban crosswalk systems and traffic signal technology that have been developed to improve the safety of elderly and handicapped pedestrians; and, guidelines for further improvements in urban design. The main conclusion of the report is that most of the needs of elderly and handicapped pedestrians can be met by improving urban crosswalk systems for the benefit of all pedestrians.

The report includes a functional specification for improved safety in pedestrian crosswalk systems and recommendations for further development. The recommendations include:

- the stimulation of more intensive use of available technology;
- the development of new traffic signal technology;
- a demonstration of the state-of-the-art in audible traffic signals;
- the development of pedestrian and motorist safety education resources.

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17. Resume

Ce rapport a passé en revue: les besoins des personnes âgées et des handicapés se déplacant à pied; la question des passages piétonniers dans les villes et les techniques mises au point pour améliorer la sécurité de ces personnes lorsqu'elles les empruntent; les lignes directrices élaborées pour améliorer davantage ces techniques. Le rapport tire la conclusion principale qu'en améliorant de façon générale les passages pour piétons, on arrivera à satisfaire la plupart des besoins exprimés par la population âgée et celle des handicapés.

Le rapport propose un guide fonctionnel concernant l'amélioration de la sécurité dans les passages piétonniers et formule les recommandations suivantes:

- intensifier l'application des technologies existantes;
- mettre au point de nouvelles techniques de signalisation;
- faire la démonstration des signaux sonores relevant des techniques de pointe;
- prévoir un programme de formation et d'éducation en matière de sécurité routière pour les piétons et les automobilistes.

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SUMMARY

Objective of the Study

The objective of this study was to develop functional specifications for the improvement of pedestrian crosswalk systems related to the needs of elderly and handicapped persons. These functional specifications could then be considered by agencies such as the Council on Uniform Traffic Control Devices for Canada, for example, when revising the existing guidelines.

Report Content

The final report provides an overview of: the needs of the elderly and handicapped when travelling as pedestrians; the urban crosswalk systems and traffic technology that have been developed to improve the safety of elderly and handicapped pedestrians; and recommendations and guidelines for further improvements in urban design. The appendix section of the report contains functional specifications for improved safety in pedestrian crosswalk systems.

Target Clientele

For the purpose of this study, "THE ELDERLY" are arbitrarily defined as those persons "AGED 65 OR MORE". It is recognized that functional aging, whether biological, psychological, or social, can begin long before a person reaches the age of 65. The benefits from improvements in pedestrian crossings would thus accrue to a much larger clientele than just the elderly and the handicapped.

"THE HANDICAPPED" are usually defined as persons of any age who have a physical, mental, or medical condition, either permanent or temporary, that limits their mobility. This is a broad definition that has been used to define "THE DISABLED", encompassing the elderly, the obese, pregnant women and those persons with injuries.

Basic Needs of Clientele

The analysis and evaluation of optional pedestrian crossing systems and technology that could be of benefit to the elderly and handicapped required the development of basic user needs criteria. The consultants rejected a classification system for the handicapped based on medical illnesses and specific disabilities in favour of one using mobility and sensory needs as the criteria. The latter classification system allowed criteria to be developed that could be used both to screen options and design new systems and technology. The following basic client needs were selected:

- ADEQUATE TIME to cross the roadway.
- BARRIER-FREE design.
- Proper ORIENTATION.
- Accurate INFORMATION.
- Ease of EDUCATION or training in usage (simplicity).

Relationship Between Pedestrian and Vehicular Traffic

Pedestrian movements and vehicular traffic are highly related elements in the transportation system. The elderly and the handicapped, being special kinds of pedestrians, particularly when they occur in large numbers, will affect sidewalk and street capacities. This often leads to special crosswalk designs, grade-separated structures and tunnels inter-connecting major activity centres.

It was recognized in this study that there is a wide range of traffic conditions impacting on the safety of pedestrians. Because special treatment of crosswalks and/or traffic signals for the benefit of the elderly and the handicapped is likely to vary with the local conditions, the following classifications were adopted:

- CENTRAL BUSINESS DISTRICT (CBD) CONDITIONS where both pedestrian and vehicle traffic volumes are high.
- AUTO DOMINANT conditions where pedestrian volumes are low and street capacity for vehicle movements is important.
- PEDESTRIAN DOMINANT conditions where street capacity for vehicles is not essential and pedestrian safety is paramount (i.e. near activity centres).
- RURAL TRAFFIC CONDITIONS where volumes of both pedestrians and vehicles are very low.

Design Considerations

To accommodate elderly and handicapped pedestrians, the time required to cross the roadway may have to be increased. This could reduce intersection capacity. It is therefore critical that any special technology analyzed for benefits to the elderly and handicapped be such that the transportation system as a whole would still be efficient. A balance between the efficient and safe movements of all pedestrians, including the elderly and the handicapped, and the needs of the vehicular traffic is required.

Current Experience

Most of the developments in improved safety for the elderly and the handicapped, both nationally and internationally, have concentrated on the needs of the visually impaired. Only very recently (since 1980) have there been significant developments in overall system design. The currently applied systems and technology in Canada include:

- Audible traffic signals (limited applications).
- Grade-separated crosswalks.
- Experiments in signal timing.
- Development of programmable signals.

International applications include:

- Widespread use of audible signals with tactile locators.
- Use of tactile cues to locate control buttons, wheelchair ramps, crosswalk boundaries and sidewalk boundaries.
- Development of better architectural design guidelines.

- Development of crosswalk design standards.
- Investigation of closed circuit information systems for the hearing and visually impaired.
- Demonstrations of "talking" traffic signals.
- Development of more sophisticated systems for the preemption of traffic signals by pedestrians.

Benefits from Technology

The potential benefits from the more intensive use of existing technology and the application of new technology are both social and economic. The major benefits are derived from improved safety for all pedestrians which has both social and economic consequences. The potential for reduced accidents was analyzed for the four application conditions, applying the user needs criteria, with the following results:

(a) CBD Conditions - The potential safety benefits from applications of new technology providing a barrier-free design are indicated to be the highest under CBD conditions because conflicts with street architecture may result in injuries over and above those created by pedestrian/vehicle conflicts. Improvements in crossing time and accurate information are indicated to be less effective due to congestion and smaller numbers of elderly and handicapped persons in the CBD areas.

(b) Auto-Dominant Conditions - These conditions, typical of major arterial streets acting as residential barriers, indicate the greatest potential benefits for improved safety through better crosswalk design.

(c) Pedestrian-Dominant Conditions - The potential to improve on the safety of access to major pedestrian activity centres ranges from low for orientation to high for improvements in time and in applying educational safety programs. Improvements in barrier-free design and more accurate information through the use of audible signals indicate modest safety benefits.

(d) Rural Conditions - Modest safety benefits are indicated for proper orientation and accurate information because, although the pedestrian volumes are low, these needs are the most troublesome.

Conclusions

Most of the needs of elderly and handicapped pedestrians can be met by improving the accessibility of urban crosswalk systems for the benefit of all pedestrians. The more specific needs of handicapped pedestrians with particular dysfunctions, such as the visually impaired for example, can be met by applying special technology developed for the purpose. Current deficiencies in crosswalk systems which impact upon the safety of all pedestrians can be overcome by better urban design. The key elements in overcoming both accessibility and safety deficiencies in urban crosswalk systems are the following:

- the national, provincial and local building codes;
- the Manual of Uniform Traffic Control Devices for Canada;
- national standards of accessibility;
- national urban design guidelines.

Recommendations

The report recommendations include:
- the stimulation of more intensive use of available technology;
- the development of new traffic signal technology;
- a demonstration of the state-of-the-art in audible traffic signals;
- the development of pedestrian and motorist safety education resources.

A functional specification for the improved safety of elderly and handicapped pedestrians (with benefits to all pedestrians) was developed in the course of this study. The specification, entitled "Improved Crosswalk Safety for Elderly and Handicapped Pedestrians - A Draft Functional Specification Including Urban Design Guidelines", is included in the appendix section of this report. It is recommended that both the report and the draft functional specification be given the widest possible distribution among institutions, agencies and departments of government (at all levels) that may be able to stimulate further research and development into, and the implementation of, improved safety standards for elderly and handicapped pedestrians.

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1. INTRODUCTION

1.1 Background

The Transportation Development Centre (TDC) of Transport Canada has sponsored a series of investigations into the mobility needs of the handicapped. More than one-third of this segment of the population are elderly persons (aged 65 or more). Because of physical disabilities and/or the deterioration of major body functions due to illnesses and the aging process, such persons are faced with particular hazards when using the street system. Since many of the elderly and the handicapped have limited finances, they do a large part of their travelling the economical way - as pedestrians, increasing their exposure to vehicles and increasing risk of injury or death.

Statistics indicate that both numerically and proportionately there are more elderly persons in Canada than ever before. There is evidence that partly because of major advances in the medical sciences, there are also more handicapped persons in the population. The implications of an aging society take on ominous tones when it is considered that the elderly have the highest pedestrian accident rate of any Canadian population segment.(1) The majority of pedestrian accidents involving the elderly, according to American Automobile Association (AAA) studies, arise at controlled intersections and mid-block crosswalks.(2) Similarly, the United States National Safety Council statistics show that two-thirds of all accidents occurring to persons of age sixty-five or more result from crossing a street, and more than 40 percent occur at intersections.(3) According to the Transport Canada studies, the pedestrian, in general, was at fault (either by behaving incorrectly or not utilizing traffic control devices properly) more than 50 percent of the time in such accidents.(4) The obvious conclusion to be reached from this body of evidence is that improvements are needed in the safety of the pedestrian mode of travel for ambulatory elderly and handicapped persons.

Pedestrian accidents involving the elderly may be associated with the progressive deterioration of major body functions. Decreasing visual and auditory sensitivity, the slowing down of decisions or of reaction time, mobility dysfunctions, and any disorientation may increase the risk of accidents. The characteristics of the aging process have been studied by gerontologists and information is available on loss of function. This information needs to be related to the design of crosswalk systems to improve pedestrian safety.

Pedestrian accidents have a substantial social and economic cost. The medical and rehabilitative therapy costs for the elderly and the handicapped already consume a large portion of government medicare funding. Pedestrian accident rates also affect insurance, police and municipal administrative costs. The cost to the elderly or handicapped pedestrian in terms of loss of function can be devastating. For some time, their economic wellbeing as well as their physical and mental

health can be affected. The evidence suggests that any improvements in traffic signals and systems that would facilitate safer pedestrian activity and therefore reduce accidents would have significant social and economic benefits.(5)

1.2 Objective of the Study

The objective of this study was to develop functional specifications for the improvement of pedestrian crosswalk systems related to the needs of elderly and handicapped persons. These functional specifications could then be considered by agencies such as the Council on Uniform Traffic Control Devices for Canada, for example, when revising the existing guidelines.

It is recognized that to achieve this objective the functional specifications must be compatible with existing local standards, techniques, and with traffic control technology. The underlying premise of the study is that improved technology for elderly and handicapped pedestrians should be of benefit to all pedestrians.

1.3 Organization of the Report

The balance of the report is organized as follows:

Chapter 2 contains a detailed description of the elderly and handicapped clientele and their needs when functioning as pedestrians. A classification system based on dysfunctions rather than disabilities is developed and presented at the close of the chapter.

Chapter 3 presents a description of the street systems that accommodate the pedestrian as well as how they are regulated and developed. A classification system to take care of the great variation in street traffic conditions is included.

Chapter 4 describes the ways in which both the system operators and the system users cope with the existing pedestrian crossing system and the impact of existing barriers and traffic conditions.

Chapter 5 presents a review of current technology that is available to accommodate the needs of the elderly and handicapped. Deficiencies in the current technology are discussed.

Chapter 6 describes the analysis process that was used to rank the potential improvements to pedestrian crossing systems and technology. Constraints to approval, manufacture and implementation are discussed.

Chapter 7 presents the conclusions of this study with respect to current and future technology and the federal mandate to stimulate application and development.

Chapter 8 presents recommendations for system and technology improvements. Further development required is described and potential demonstration and education programs are suggested.

2. THE CLIENTELE AND THEIR NEEDS

For the purpose of this study, "THE ELDERLY" are arbitrarily defined as those persons "AGED 65 OR MORE". It is recognized that functional aging, whether biological, psychological, or social, can begin long before a person reaches the age of 65. The benefits from improvements in pedestrian crossings would thus accrue to a much larger clientele than just the elderly and the handicapped.

"THE HANDICAPPED" are usually defined as persons of any age who have a physical, mental or medical condition, either permanent or temporary, that limits their mobility. This is a broad definition that has been used to define "THE DISABLED", encompassing the elderly, the obese, pregnant women and those persons with injuries.(6) For the purpose of this study, it has been necessary to define more specific dysfunction groups which are described in the following sections and sub-sections of this report.

2.1 The Ambulatory Elderly

This classification is intended to include those persons who may experience some loss of function due to the aging process but who are not otherwise considered to be mobility handicapped. The needs of the handicapped elderly are dealt with under the particular dysfunction (or dysfunctions) that impair their use of the street system.

2.1.1 Vision and Hearing Changes

Vision is the first sensory system to show appreciable changes due to aging, even in the absence of any disease. Typically the field of vision shrinks both laterally and vertically, visual sharpness (acuity) diminishes, and adaptation to lighting changes is slower.(7) The elderly also have problems with dynamic visual acuity (seeing objects in motion). The elderly are less efficient and slower at moving their eyes, and have poorer depth perception. Reduced peripheral vision may be exacerbated by any loss of head movement due to arthritic problems. With aging, the eye becomes less efficient at focusing on objects near at hand (presbyopia), less able to adapt to changing light conditions and less sensitive to colour, especially short wave length colours such as blue and green. These effects are byproducts of structural changes in the lens and retina of the eye and cannot be fully compensated for by purchasing or increasing the strength of one's glasses. With persons over 70, in particular, there is a dramatic increase in disease processes which influence the function of the eyes. For many older people, driving a car at night becomes problematic and reading normal print books and newspapers may be difficult. In addition, visual changes increase the risk of accidents, particularly falls. Depth perception is impaired in later life. This can be exacerbated by low levels of illumination. Not seeing the curb because it is in shadow may lead to falls. Falls also occur because the loss of depth

perception fails to disclose small obstructions in the travel path. The elderly also have reduced contrast sensitivity.(8)(9)

The above factors suggest that visual information needed at street crossings should be within a compact field of view and should not be impaired by extremes of light and shadow. Graphics and other printed information need to be bold and in high contrast to their background material. Large definite shapes are desirable. The size of type and graphics must relate to distance from the reader.(10)

Auditory changes typically take the form of a loss of sensitivity for high frequency sounds (presbycusis). Losses appear to be a joint product of age changes in the structure of the ear and the cumulative effects of exposure to noise in the environment. Loss of auditory sensitivity has a number of potentially serious effects. First, inability to hear certain sounds restricts environmental input that may be needed for safe and competent function. Since hearing sensitivity decreases, especially for the higher frequencies, and background noise impairs understanding, the frequencies used for audible signals must be carefully selected.(11)

2.1.2 Touch Sensitivity (Somesthesis)

The sense of touch is generally subsumed in the larger category of somesthesis. Somesthesis includes sensations that arise from normal and intensive stimulation of the skin, viscera, and kinesthesis - the muscle and joint sense. While age differences in several measures of somesthetic sensitivity have been reported, losses are by no means general in the aged population and it seems likely that certain changes may result from the accumulated effects of disease and injury rather than aging per se.

Sensitivity to touch has been shown to be less for older than for younger people. The degree of loss of sensitivity varies across different parts of the body. The skin of the palm of the hand and the sole of the foot demonstrate marked changes, as does the cornea of the eye.(12)

A decline in touch sensitivity appears to be a result of structural changes in the skin itself. In old age, there is atrophy in the dermis, epidermis and subcutaneous tissue. There is also a diminished elasticity. The result is that the skin becomes less and less sensitive to stimulation. Research also suggests that the thermoreceptors in the skin lose efficiency in old age, hence the desirability of non-conductive handrails for cold weather conditions.

A decline in the ability to sense vibration has been reported in numerous investigations. The loss appears to begin at approximately 50 years of age, and is uniform across a wide range of frequencies. As with touch sensitivity, the loss is more pronounced in the lower than the upper extremities. That is, the feet show a greater change in sensitivity to vibrotactical stimulation than do the hands. A number of explanations have been offered for these changes including decreases in spinal root nerves, impaired circulation and changes in individual

nerve cells. These findings suggest that tactile devices should be designed for hand and arm stimulation. Indentations or changes in pavement texture acting as tactile cues need to be more pronounced for this user group, and tactile vibration devices need to be more carefully evaluated.(13)

2.1.3 Psycho-Motor Slowing

One of the most widespread changes observed in later life is a slowing of behavior. Birren (1980), after reviewing 26 studies of simple reaction time of young and old subjects, found, on the average, a 20 percent difference between the two groups.(14) Age differences in speed of response have also been repeatedly observed on more complex reaction time tasks such as those requiring the person to select one of several possible responses after presentation of a stimulus. Other examples of response slowing on complex tasks include tests of intelligence which show the most marked age differences on items demanding a rapid response. The time required to retrieve information from memory is also longer for older than for younger persons.(15)

Considerable research has been directed at ascertaining whether slowing of behavior is a reflection of alterations in the sense organs which limit access to information, changes in the speed of nerve conduction, muscular limitations, or whether slowing is due to changes in the central nervous system which affect the processing of information. The most widely accepted explanation of response slowing is that it reflects changes in the central nervous system that result in a diminished ability to integrate and respond to stimulation.

One of the most important findings from movement studies is that greater changes occur with age when movements cannot be prepared in advance, especially when a rapid series of different movements is called for. The implication of this finding is that older people may be less able than younger people to deal with sudden, unanticipated environmental demands such as can occur when crossing a street. Another conclusion to be drawn from the literature on psycho-motor skills is that older people will require more time when dealing with routine, but complex, life matters, particularly those involving the need to simultaneously and rapidly process large amounts of information and/or where multiple responses are required. Age changes in the central nervous system also appear to make it more difficult for older people to ignore irrelevant aspects of a situation. This implies a need for careful design and placement of traffic signs and signals so as to provide only essential information and eliminate extra confusing details and "clutter".

Although the experimental literature indicates that it may not be possible to eliminate age-group differences, exercise, practice and motivation to perform at a high level have all been found to increase speed of response.(16)

2.1.4 Physical Orientation Problems

Acute physical illness, dehydration, malnutrition, biochemical imbalance, drugs, as well as Alzheimer's and related diseases can produce confusion in elderly persons.(17) Temporary confusion may also result from a move from a familiar to an unfamiliar environment. Adequate lighting and good street signing may assist the person with orientation problems. Educational programs focusing on familiarizing the newly relocated individual with his/her immediate neighbourhood may also be helpful. Assistance is often obtained from a variety of sources including occupational therapists, "activity aides", the staff of community centres, support groups and volunteer social workers. Another aspect of the orientation problem is that the elderly have more difficulty than younger persons in dividing their attention between: several inputs, input and holding information in memory, or between holding and responding. This can lead to confusion and/or anxiety, which may contribute to accidents at crosswalks.(18)(19)

2.2 The Ambulatory Handicapped

This classification includes persons who are fully mobile except for specific disabilities impairing their safety as a pedestrian based on clinical definitions.

2.2.1 The Visually Impaired

The "VISUALLY IMPAIRED" includes those persons who have difficulty seeing even with corrective lenses as well as the "LEGALLY BLIND". A person is considered "LEGALLY BLIND" if the visual acuity in both eyes with proper refractive lenses is 2200 (660) or less with the Mellin chart, or equivalent, or if the greatest diameter of the field of vision in both eyes is less than 20^{o}.

Most visually-impaired persons travel alone to work, recreation, shopping and home, avoiding hazards and finding their way through confusing and complex environments. Other visually-impaired persons are not so skilled as travelers. For these persons, the environment can be confusing and hazardous, and special design attention is required to make pedestrian crossings accessible to them.

Design for visually-impaired persons presents a special challenge. The design professions are intensely visual and it is difficult for designers to empathize with a user who has little or no usable vision. Designers must take into consideration the fact that many of the blind are also elderly and suffer from other degenerative conditions that tend to limit balance, stamina, reaction time, and general motor ability. (These problems were discussed in Section 2.1.1.)

Visually-impaired persons should be taught to exploit their other senses to perceive the environment.(20) Examples of this include:

(a) Vision - light perception may be used to discriminate between sunlight and shadow, day and night, and north, south, east and west.

Figure 2-1 Illustrating One Method of Mobility for the Visually Impaired
(Courtesy Hickling Partners Inc.)

(b) Hearing - the reverberation of sounds in a space will give an impression of the location of objects and the size of the space. The location of a noise, such as that which a truck or automobile generates, will be suggested by the direction and magnitude of the sound. The frequency distribution will help identify what produced the sound.

(c) Touch - an increase in wind movement against the skin may suggest where a street corner is. External heat (or cold) sources can be felt - sunlight on the skin may indicate direction and location. Differences in paving materials may act as a landmark and the long cane can provide tactile (and auditory) information.

(d) Balance - a developed kinesthetic sense will convey information on the gradients of a hill and where a ramp starts or ends.

For the designers these abilities and disabilities have a number of implications:

- Because of their distinctiveness and simplicity, some street layouts are easier to understand and negotiate than others.
- Environmental information may be communicated nonvisually using audible and tactile messages.
- The understanding and safe use of the environment can be greatly enhanced for the large proportion of visually-impaired persons who have some usable vision. These persons benefit from the use of large signs, effective lighting, and other visual strategies.
- Provision for maintenance of the crosswalk is essential to prevent a build-up of ice, snow or debris which can impair balance.

2.2.2 The Hearing Impaired

The "HEARING IMPAIRED" includes those persons who cannot hear adequately with the use of a hearing aid, the congenitally deaf and persons who become deaf through an accident or illness. Such persons depend mainly on visual communications for information on their environment. Some hearing-impaired persons can distinguish sounds through the use of a hearing aid, but are not able to distinguish and understand words. Some hearing-impaired persons experience a phenomenon called 'recruitment', in which noises at low frequencies sound much quieter than they would to a normal-hearing person or are not understood at all. Persons with 'recruitment' are less able to hear low-decibel noises, such as fans or engines.(21)

2.2.3 Touch Sensitivity Problems

Touch sensitivity problems may be experienced by persons with cerebral palsy, multiple sclerosis and various forms of arthritis. In some cases these persons may not have sufficient strength or co-ordination to activate a poorly-designed control device. Many of these persons use electric wheelchairs to accommodate physical weakness

or travel fatigue. The effects of the aging process on touch sensitivity were previously discussed in Section 2.1.2.(13)

2.2.4 Reading Disabilities

Persons with reading disabilities include the illiterate, persons for whom English or French is a second language, and persons affected by dyslexia. Persons affected by dyslexia tend to perceive alpha-numeric instructions in a reversed or chaotic order. Such persons are more dependent upon oral instructions and simple graphic shapes, although oral instructions are preferred. They would be aided by "talking signs", for example.(22)

There are a substantial number of pedestrians who are illiterate with respect to traffic signing and regulations. Although traffic signs use international symbols, elderly persons who have not taken a driving test may not be aware of the meanings of the symbols. New Canadians also have difficulty in understanding differences in traffic regulations.(23)

2.3 Semi-Ambulatory Handicapped

The semi-ambulatory handicapped include those with severe medical problems, such as heart disease, hemophilia, and cerebral palsy, for example; disabled persons using prosthetic devices that may limit their walking speed and dexterity and those using walking aids such as canes, crutches and walking frames (walkers). This segment of the handicapped population generally require more travel time than those using wheelchairs for a typical street crossing. Such persons may also use other devices such as a baby's stroller or perambulator, or a grocery cart as a walking aid, so attention must be given to the accommodation of various wheeled devices. Hazards such as gratings which may trap a cane or other walking device must be avoided.(24)

Persons with arthritis must conserve as much energy as possible. These persons expend more energy in performing tasks than others do because of pain, muscle weakness, stiffness in joints and general fatigue. Such persons are severely inconvenienced by pedestrian systems that are not designed to minimize human energy consumption. The semi-ambulatory include persons with severe heart problems and those who may have experienced a stroke. Such persons receive less consideration from vehicle operators who do not perceive their disability. Occupational therapists often advise such persons to use a walking aid such as a cane to act as a signal to vehicle operators.

2.3.1 Those Using Prosthetic Devices

This includes disabled persons fitted with artificial limbs, or "drop-foot splints", which may reduce their mobility. Their needs are similar to persons suffering from arthritis where their dexterity and walking speed may be reduced. They are adversely affected by uneven road surface conditions and unusually high curbs. Persons who have experienced a stroke have difficulty with toe clearances on high curbs.

2.3.2 Those Using Walking Aids

There are two basic devices in use by persons with reduced strength and dexterity in their lower limbs. These are a variety of canes, which are used mainly for balance, and four-legged aluminum walking frames, which are used both for balance and physical support. Persons using such devices may be relatively agile, but are usually the slowest pedestrians among the semi-ambulatory handicapped. It should be noted that such persons are often in greater safety when crossing streets because motorists react to their walking device.(25)

2.4 Wheelchair Users

This classification includes all persons using wheelchairs for mobility. Many of these persons may also experience other disabilities. To simplify the classification process in this study, sense dysfunctions (discussed previously) have been separated from physical dysfunctions. Except for the very frail, persons using wheelchairs (when curb cuts are provided) often move as quickly as other pedestrians.

2.4.1 Physical Barriers

Provincial and local government building codes provide basic standards and guidelines for building accessibility for the physically handicapped. The design of urban street architecture requires similar guidelines for the safe movement of physically handicapped pedestrians. The basic needs for the design of the approach to pedestrian crosswalks and the actual crosswalk area include:(26)

- Minimum widths of 1520 mm.
- A hard, relatively level, and non-skid surface.
- Walkways in a continuous plane.
- Well-defined crosswalk boundaries, preferably of different texture.
- A gradient maximum of five percent (5%).
- A minimum curb height of 150 mm and a maximum curb height of 250 mm.
- A good standard of lighting.
- Curb ramps offset to path of travel and of different colours and textures if possible.
- An absence of overhead obstructions above the walkways.
- Unobstructed level areas at the beginning and end of wheelchair ramps.
- Threshold barriers of less than 12 mm in height.
- Free access to pedestrian-activated signal controls.
- An absence of hazards due to the temporary storage or placement of street furniture and service containers, e.g. mail boxes, garbage containers, flower boxes, etc.
- Designed for easy removal of ice, snow and debris.

2.4.2 Multiple Dysfunctions

The most common occurrence of multiple dysfunction, particularly among the elderly, is a combination of some form of arthritis along with sensory disabilities or loss of mobility. Combinations of neurological dysfunctions along with physical disabilities are common. Fractures as a result of accidents to the elderly and visually impaired persons can add to the impact of degenerative arthritis. The impact of multiple dysfunctions to wheelchair users often results in fatigue and the inability to operate a manual wheelchair. This usually requires the individual to obtain an electric-powered wheelchair.(27)

2.5 Summary of Needs Criteria Used in the Analysis

The analysis and evaluation of optional pedestrian crossing systems and technology that could be of benefit to the elderly and handicapped required the selection of some basic user needs criteria. The consultants rejected a classification system for the handicapped based on medical illnesses and specific disabilities in favour of one using mobility and sensory needs as the criteria. The latter classification system allowed user needs criteria to be developed that could be used both to screen options and design new systems and technology.

The analysis method developed included the following basic needs:

- ADEQUATE TIME to cross the roadway.
- BARRIER-FREE design.
- Proper ORIENTATION.
- Accurate INFORMATION.
- Ease of EDUCATION or training in usage (simplicity).

These needs criteria are used in Chapter 6 to evaluate optional systems and technology. Specifications for new systems and technology based on the needs criteria are described in Chapter 7, Section 7.3. Table 2-1 presents a summary of the user needs criteria developed and the segments of the elderly and handicapped (E & H) that apply to each.

Needs Criteria	E & H Segments Affected		
	Most Affected	Affected	Inconvenienced
ADEQUATE TIME	Semi-ambulatory; those with multiple dysfunctions	Persons using wheelchairs	The ambulatory elderly
BARRIER FREE	Visually impaired; persons using wheelchairs	Semi-ambulatory	The ambulatory elderly; persons with Cerebral Palsy
ORIENTATION	Visually impaired; Some segments of the elderly; the mentally retarded	Some segments of the elderly	The hearing impaired
INFORMATION	Visually impaired; the mentally retarded	Hearing impaired; reading impaired	The ambulatory elderly
EDUCATION	The ambulatory elderly	The ambulatory elderly	All segments

Table 2-1 Relative Influence of Various Needs Criteria on E & H Segments

3. THE PEDESTRIAN CROSSING SYSTEM

Pedestrian movements and vehicular traffic are highly related elements in the transportation system. The elderly and the handicapped, being a special kind of pedestrian, particularly when they occur in large numbers, will affect sidewalk and street capacities. This often leads to special crosswalk designs, grade separated structures and tunnels inter-connecting major activity centres.

In this chapter, the philosophy of the pedestrian and vehicular traffic control is discussed. In particular, the rights and duties of the pedestrian are addressed as they pertain to applicable legislation. An understanding of current laws, traffic engineering principles and the characteristics of pedestrians will assist the development of an effective and equitable solution to the transportation needs of the elderly and handicapped.

3.1 The Regulators

The pedestrian crossing system is part of the overall street and roadway systems which generally are regulated firstly by the provincial motor vehicle acts and secondly by the traffic bylaws of municipal governments. For example: Part 3, Section 115 of the Motor Vehicle Act of the Province of British Columbia (RSBC 1979, Chapter 288, as amended) defines a crosswalk as:

(a) a portion of the roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by signs or by lines or other markings on the surface; or
(b) the portion of a highway at an intersection that is included within the connection of the lateral lines of the sidewalks on the opposite sides of the highway, or within the extension of the lateral lines of the sidewalk on one side of the highway, measured from the curbs, or in the absence of the curbs, from the edge of the roadway.

It should be noted that the same act also stipulates the duties of vehicle drivers and pedestrians. It states that a pedestrian shall not leave a curb or other place of safety and shall not run into the path of a vehicle which could not be stopped on time. It also states that when a pedestrian is crossing a highway at a point not in a crosswalk, the pedestrian shall yield the right-of-way to a vehicle.

The provincial motor vehicle acts do not deal with elderly and handicapped pedestrians specifically. They are considered to be pedestrians in general. For all intents and purposes, elderly and handicapped pedestrians must observe the same rules as any other pedestrians.

Responsibility for the installation of crosswalks and traffic signal systems generally falls within the jurisdiction of the local

government. City and district councils usually control and regulate traffic by bylaws under the power of the provincial municipal acts and the motor vehicle acts. Marked crosswalks other than those located at intersections are usually installed by resolutions of a municipal council.

Because of the mainly local jurisdiction, the installation of traffic signals and crosswalks is very sensitive to the local political process. Municipal engineers and civic advisory committees usually try to establish entrenched standards called "warrants" for installations based on vehicular and pedestrian traffic volumes, accident records and the special needs of schools and other institutions. In spite of this, it is common for special consideration to be given to requests from advocate groups where no particular warrant for a traffic signal or special crosswalk treatment exists. This has generally benefited the handicapped as a special interest group. Section A2.13 of the Manual of Uniform Traffic Control Devices for Canada published by the Roads and Transportation Association of Canada (RTAC) describes a pedestrian crossing control as follows:

> "The problem of meeting demands for the control and protection of pedestrians, and in particular special classes of pedestrians such as children and senior citizens, is complex and difficult. Understandably considerable public pressure is exerted from various organizations, including parent and teacher groups, for the installation of signs, signals, and pavement markings for this purpose. These demands made upon civic officials are frequently, economically, and tactically impossible to meet. In addition, a wide variation in Canadian regulations exists at the present time and in particular with respect to school signing practices.
>
> The manual does not attempt to deal with regulations. Signs are presented herein that can be adapted to various types of prevailing regulations. Normally in coping with a given problem a combination of regulatory signs, warning signs, and pavement markings will be required. This Division presents those signs which are regulatory in nature and the reader should refer to Section A3.60 for further information with respect to Pedestrian Warning Signs."

In some cases, the installation of crosswalks is the responsibility of the province because some highways are classified as provincial highways. In other cases a special authority has been set up, such as the Halifax Traffic Authority, which was created by the Province of Nova Scotia. Another example is Wascana Centre Authority in Regina, which has authority over traffic within a large institutional/recreational complex. These authorities are much less sensitive to local pressure groups.

3.2 System Requirements

The current techniques used in the design and installation of pedestrian crosswalks have evolved from decades of local development and experience. There is no standard evaluation process for the

installation of pedestrian crosswalks. The major guidelines for school crosswalks are contained in Section A2.13.01 of the Manual of Uniform Traffic Control Devices for Canada. The manual also has established standards for crosswalk lines. Crosswalk lines are transverse lines, white in colour, and have a width of 0.1 to 0.2 metres. A typical urban intersection layout showing the crosswalks is shown in Figure 3.1. The width of crosswalk varies and is considered a function of pedestrian volumes.

3.3 The Need for Traffic Signals (See Chapter 4)

The function of a traffic signal is to assign the right-of-way of vehicles and pedestrians. This is often necessary on major arterial streets where cross traffic would be seriously delayed by high volume traffic on the arterial. The proportion of "green time" given to each direction is based on the relative volumes of traffic in each direction, and the duration required for pedestrians to cross the roadway based on an average walking speed of 1.2 metres per second. Warrants for installing signals are published in the Manual of Uniform Traffic Control Devices for Canada. These are based on a review of traffic and pedestrian volumes and accident patterns.

3.4 System Operation and Maintenance

Traffic signals and pedestrian crosswalks are usually maintained by the same jurisdictions that approved their installation. Maintenance of systems is often affected by budget constraints. The activation of signals in the smaller communities is often controlled by the local police jurisdiction. The police in small communities often turn the signals off at night effectively changing the signal to a "STOP" sign. The traffic police or fire department can usually override the signals in an emergency. In large cities the trend is toward linked systems using central computer controls.

3.5 Pedestrian Crossing Design

A pedestrian crosswalk is a traffic control device designed to guide pedestrians across the roadway. It is not intended as a protective device to save lives but to warn motorists of a high pedestrian flow location. Crosswalks can be "marked" or "unmarked". Marked crosswalks are usually designated by white lines indicating a "stop line" for motorists. Crosswalk warning signs are often used. Unmarked crosswalks are at intersections and are defined by the extension of sidewalk boundaries. Early crosswalk designs often included safety islands and traffic barriers to provide refuge for pedestrians. These proved to increase vehicle accidents and are generally being eliminated in favour of wide medians, where possible.

3.5.1 Central Business District Applications

In the Central Business District (CBD) of urban communities, pedestrian crosswalks are usually marked and controlled by "WALK"/"DON'T WALK" signals. At CBD intersections, vehicle turning movements are usually allowed. To balance the need for pedestrian

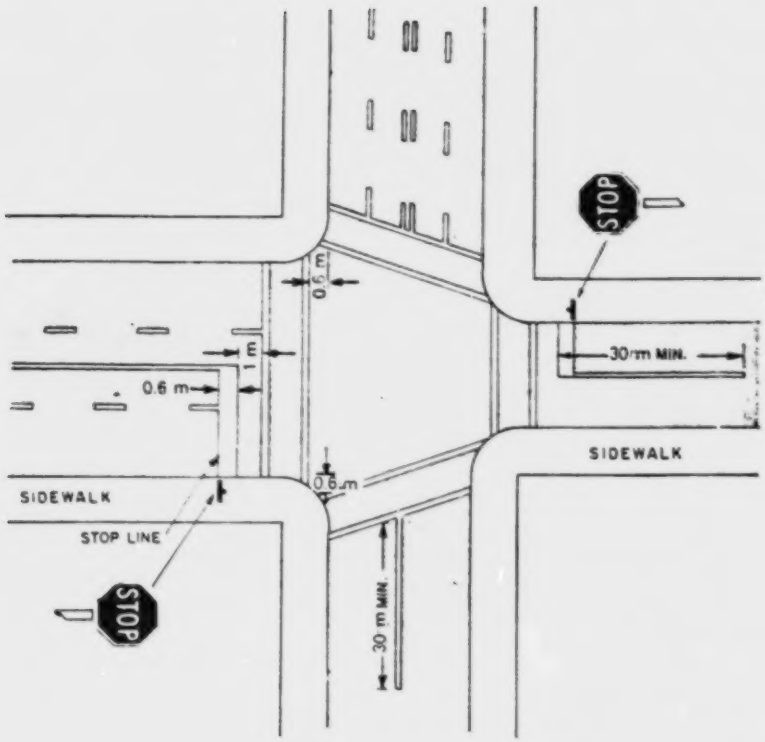

Figure 3-1 Standard Urban Intersection
(Reprinted from "Uniform Traffic Control Devices for Canada", 1976)

safety and vehicular capacity at intersections, pedestrian movements are controlled by these "WALK"/"DON'T WALK" signals to allow some green time for turning vehicles. In addition, the crosswalks, marked by two white lines, are intended to channel pedestrian flow within them. In high pedestrian and vehicular volume areas such as CBD's, this approach is desirable for safety and efficiency reasons.

3.5.2 Arterial and Collector Street Applications

In areas outside the CBD, pedestrian crosswalks are usually considered for arterial and collector streets. They are not usually installed in local residential areas because of low vehicular and pedestrian volumes. On arterial and collector streets, unmarked crosswalks may exist at intersections. Marked crosswalks are usually installed for schools and playgrounds to indicate high pedestrian flows to vehicle operators at specific times and locations. There are standard warning signs and crosswalk signs for school and playground crossings as is stipulated in the Manual of Uniform Traffic Control Devices for Canada.

In addition to marked school crosswalks, school patrols and signals are sometimes used. The purpose of these additional measures is to control the flow of school children to the marked crosswalk and to allow them to cross safely by directing them. Marked crosswalks are not usually installed at unsafe locations, such as areas with poor visibility, on the top or bottom of a steep hill, etc. Pedestrians crossing arterial and collector streets need to be directed to cross at safe locations where vehicle operators can recognize that there is high pedestrian volume, where there is good visibility and good topographic conditions for vehicles to stop safely.

In some urban communities, where high pedestrian volumes cross arterial and collector streets, pedestrian-actuated traffic signals are used. At intersections, traffic signals are installed for both the arterial and collector road traffic (all four corners) with only a flashing red signal for the minor street. A single set of "WALK"/"DON'T WALK" signals is installed at locations other than an intersection. Pedestrians must activate the crosswalk signals by pushing a button.

3.5.3 Warrants for Special Applications

Traffic signals may also be installed on school crossings, rural roadways or in shopping centres where high volumes of pedestrians cross. Most of the signals (perhaps all) are installed according to warrants. Political issues usually have some bearing on the warrants for school crossings.

3.6 Application Classifications Used in the Analysis

It was recognized early in this study that there is a wide range of traffic conditions impacting on the safety of pedestrians. These conditions range from high volumes of vehicles and pedestrians in the central business districts of cities to arterial and collector streets

where vehicles outnumber pedestrians to residential neighbourhoods and shopping centres where pedestrians outnumber vehicles. Because special treatment of crosswalks and/or traffic signals for the benefit of the elderly and handicapped is likely to vary with the local conditions, the following classifications were adopted:

- CBD CONDITIONS where both pedestrian and vehicle traffic volumes are high.
- AUTO DOMINANT conditions where pedestrian volumes are low and street capacity for vehicle movements is important.
- PEDESTRIAN DOMINANT conditions where street capacity for vehicles is not essential and pedestrian safety is paramount (i.e. near activity centres).
- RURAL CONDITIONS where volumes of pedestrians and vehicles are very low.

4. THE DESIGN OF SIGNALIZED PEDESTRIAN CROSSINGS

One of the elements that affects signalized intersection capacities is the ratio of green time to total signal cycle time. This is one of the reasons for installing "WALK", and "DON'T WALK" signals. Pedestrians require a minimum time to cross the road and their movements at intersections reduce vehicle capacity by delaying turning vehicles. Vehicles waiting to turn left or right must do so after the pedestrians have cleared the crosswalk. The "WALK" and "DON'T WALK" signals are used to regulate pedestrian movements to allow a reasonable time for turning movements, thereby maintaining a level of capacity at the intersection. Typical traffic signal heads are shown in Figure 4-1. Local variations in signal heads having a diamond shape for the red signal and a square shape for the green signal are being used in the Province of Quebec.

To accommodate elderly and handicapped pedestrians, the time required to cross the roadway may have to be increased. This could reduce the intersection capacity in two ways: by the reduction of green time in the cycle, and by the delay of turning vehicles.

It is therefore critical to review special crosswalk treatment for the elderly and handicapped to ensure that the transportation system as a whole would still be efficient. There should be a balance between the efficient and safe movements of all pedestrians, including the elderly and the handicapped, and the needs of the vehicular traffic.

4.1 Pedestrian Crossing Time

Traffic signals are generally set to provide a "WALK" clearance interval of sufficient time for a pedestrian to safely cross a roadway at a walking speed of 1.2 metres per second. Pedestrians entering the crosswalk when the "DON'T WALK" signal is displayed often do not have sufficient time to cross within the "GREEN" phase. Some communities have considered extending the timing to accommodate a walking speed of 0.9 metres per second when significant numbers of the elderly or handicapped persons use a particular crosswalk (at residences and activity centres).(28) This extension would likely accommodate all but the severely handicapped.

Occupational therapists advise the elderly and handicapped to ensure sufficient crossing time by waiting for the traffic lights to complete a full cycle so that their crossing is initiated at the beginning of the "GREEN" or "WALK" phases. Should these pedestrians arrive at a time that the signal is already displaying a "GREEN or "WALK" message, they have been observed to wait for a full signal cycle to ensure that the maximum crossing time is available.

Since many persons using wheelchairs are able to move at a walking speed (at least for short distances), the most severely affected by

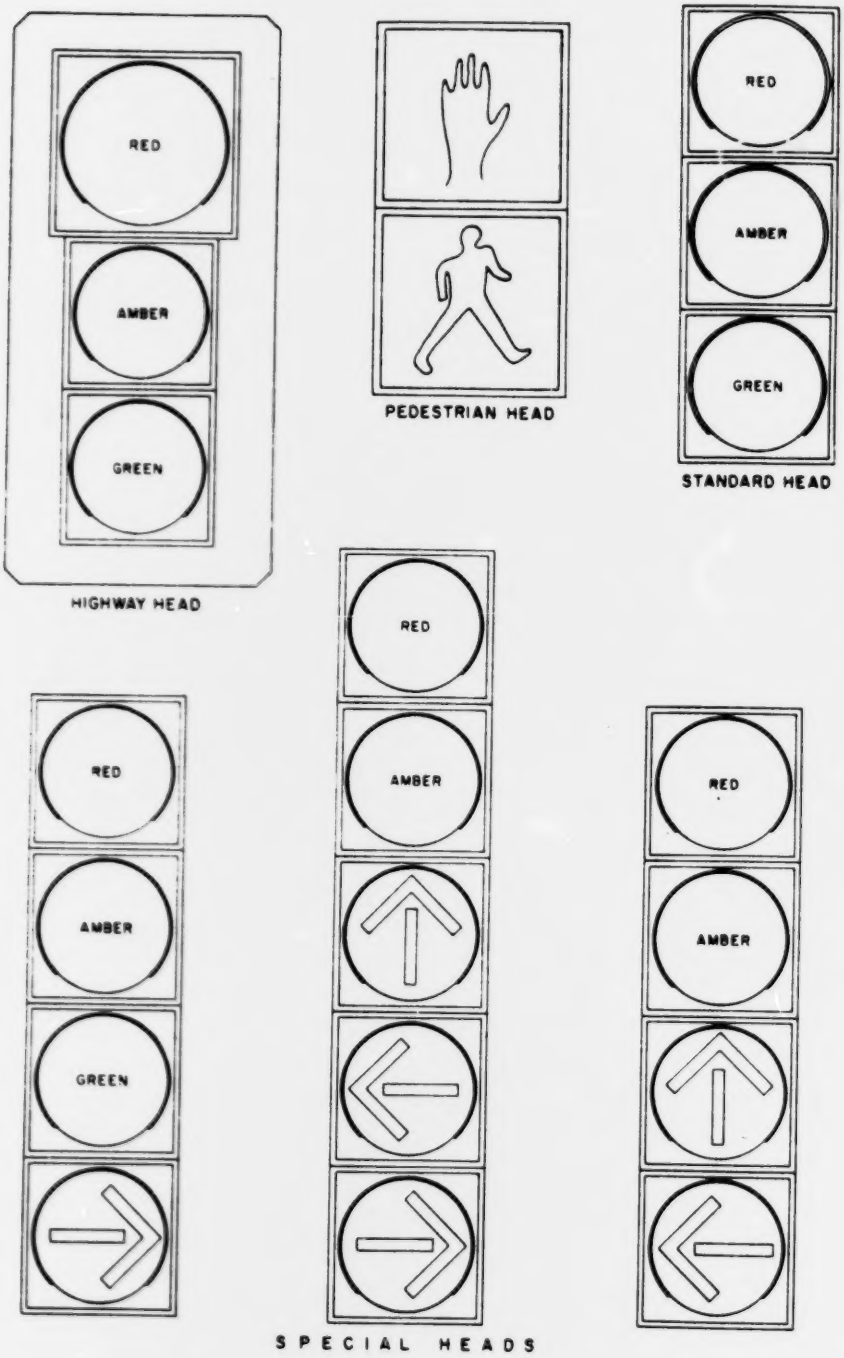

Figure 4-1 Typical Traffic Signal Heads
(Reprinted from "Uniform Traffic
Control Devices for Canada", 1976)

signal timing are those using walking aids. Such persons must be particularly careful in their selection of crosswalks. They may need to select crosswalks that contain "safety islands" at mid-point. Some of them may try to select neighbourhood crosswalks where familiarity with vehicular traffic conditions may allow them to pre-empt a portion of the vehicular "GREEN" time. Still others may simply insist on their right to cross whether they have the right-of-way or not, creating traffic hazards and exposing themselves to potential injuries or death.

4.2 Crosswalk Entrance Barriers and Hazards

There are two major areas of concern, mainly to the visually impaired. The first includes hazards due to the placement of such items as sign poles, mail boxes, garbage containers and traffic signal controllers at or near the entrance to the crosswalk. The second area of concern is the construction of wheelchair ramps at the end of the sidewalk immediately prior to the pedestrian crosswalk.

The first problem is usually overcome by good architectural design. Figure 4-2 (d) illustrates the use of materials of varying texture to allow the visually impaired to avoid obstructions. Figure 4-2 (e) shows the preferred location of wheelchair ramps so that the visually impaired are able to locate the curb edge of the sidewalk. Persons whose vision is severely impaired are trained to detect changes in surface texture and elevation with a "long cane". An alternative to the use of offset ramps shown in Figure 4-2 (e) is to change the texture on the ramp itself, however this is not as definite as an elevation change. Familiarization with street hazards improves walking speed. Removal of hazards and good roadway maintenance to remove debris at crosswalks benefits all pedestrians, is particularly important to the elderly and handicapped, and critical for the safe movement of the visually impaired.

4.3 Signal Control Buttons

Many traffic signal installations are of the semi-activated type. These signals allow vehicular traffic on major arterials to have the right-of-way until the crossing signal is activated. This type of installation is normally used where pedestrian traffic is infrequent. To operate these signals, the pedestrian is required to push a control button which activates the traffic control to interrupt either the "RED" time or the "DON'T WALK" time to provide crossing time for the pedestrian. Section A4.55 of the Manual of Uniform Traffic Control Devices for Canada outlines a standard height of 1.25 metres for the installation of pedestrian-activated control buttons.

There are a number of problems with current signal activation buttons. The handicapped pedestrian must be able to locate them, gain access to them and have sufficient strength to operate the control button. There are a variety of control buttons in use at present. Some are large, spring-loaded controls and others are small buttons that need a strong finger to operate. Those with arthritis in the hands or arms may experience difficulty with these controls. Such devices, because of their design, are often difficult to operate while

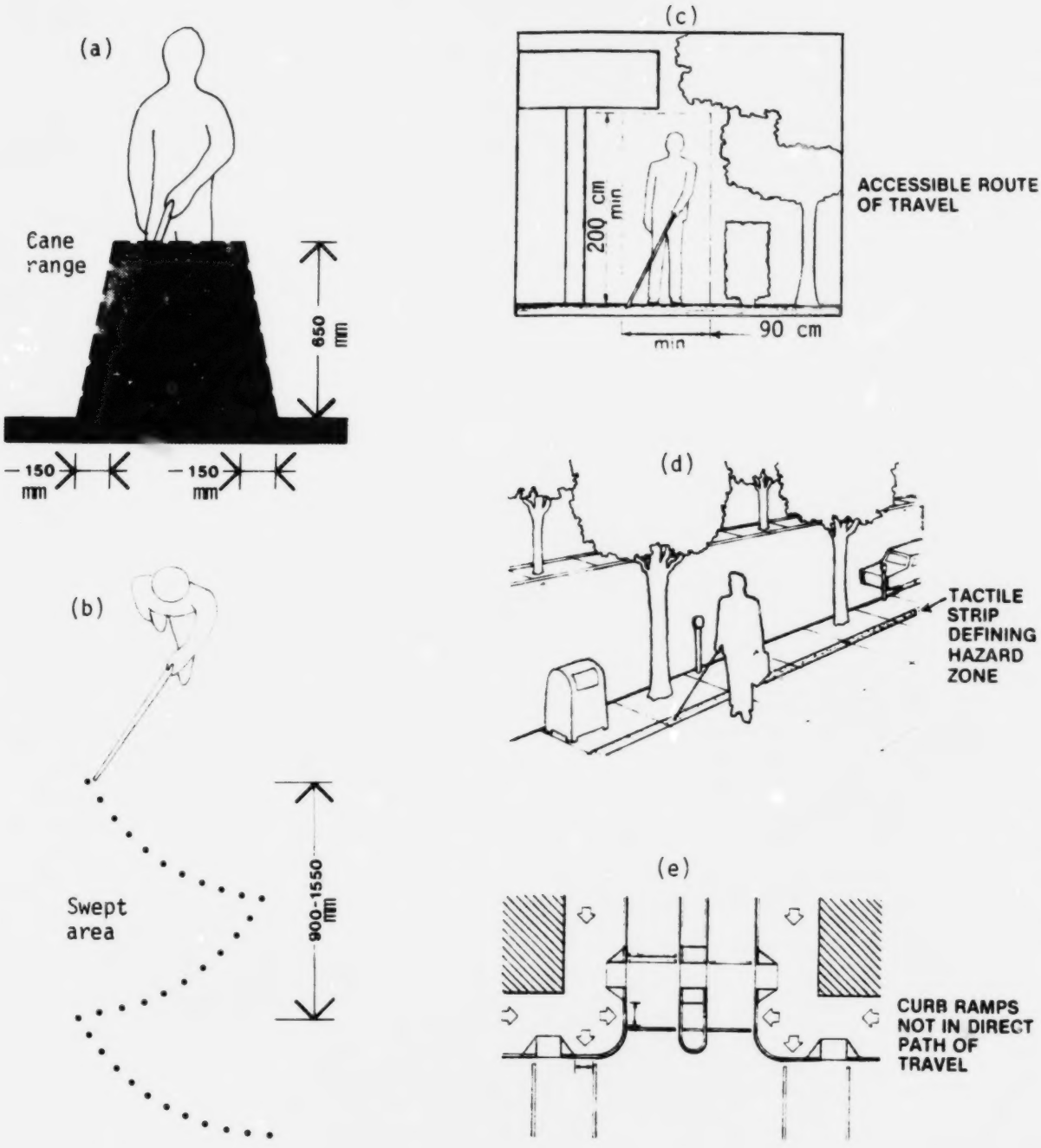

Figure 4-2 Mobility of the Visually Impaired Using a "Long Cane"

(Courtesy "Access Information Bulletin" (20) and "Barrier Free Design") (29)

wearing gloves or mitts, which the elderly are more likely to do in cold weather. Some are difficult to get to in a wheelchair because of their placement away from the area of travel or because of the height of the control.

4.4 Crosswalk Design Constraints

Crosswalk design constraints vary according to their location. For the purpose of this study, four classifications were developed in Chapter 3 for evaulation of current design. These included: the central business district (CBD), crosswalks on major arterial streets, crosswalks near activity centres, and crosswalks on lower volume collector streets and in lower density areas. This last area would encompass rural applications, while the arterial street crossings would be similar to the internal needs at busy shopping centres.

It is more difficult to implement special traffic signals for the elderly and handicapped in central business districts because of the high volumes of pedestrians and traffic. The noise level is usually high in a downtown environment. Unless adequate space is provided in the crosswalk facilities, mobility for the handicapped is difficult. There are often physical constraints such as the availability of land for sidewalks.

Midblock pedestrian signals interrupt the vehicle traffic progression and therefore reduce roadway capacity. This also applies to semi-activated signals for crosswalks. Most municipalities do not encourage mid-block crosswalks because they are considered to be unsafe. If a mid-block crosswalk must be installed, it is usually installed for the purpose of warning motorists of a high pedestrian volume location.

Midblock crosswalks are considered unsafe because pedestrians do not usually follow them to cross the roadway. In rural and suburban areas, midblock crosswalks may be acceptable with adequate signing and design. In CBD areas, where there are many commercial and regulatory signs with street architecture, landscaping and light standards, the effectiveness of pedestrian crosswalks, signs and signals are diminished. For safety in design, pedestrians should not be encouraged to cross any roadway at a location unexpected by vehicle operators.

4.5 Signal Status Information

Signal status information is of primary interest to the pedestrian. Standard placement of red, yellow and green signals is used to aid those with colour vision impairments. A great variety of audible signals are being used to aid in alerting visually-impaired pedestrians as to the signal status. There are differences of opinion on the value of audible signals among the users and the advocate agencies for the visually impaired. The Canadian National Institute for the Blind (CNIB) takes the position that there is no substitute for the development of good travel skills by blind and visually-impaired individuals, but recognizes that certain adaptations within the

environment, i.e. audible traffic signals, can be of assistance in facilitating safe and effective travel.(30)

Audible traffic signals can be found in most major cities across Canada (see Section 5.1.2). They are generally located in areas of high traffic volume and often in proximity to Canadian National Institute for the Blind (CNIB) facilities where there is obviously a larger concentration of blind and visually impaired individuals. Most devices are activated by pressing a button that allows a signal to be emitted when it is safe to cross a given area. The conclusion of the signal denotes the reverse situation. It is important to note that in some other countries the reverse may be the case. Even with audible signal status information, reliance on audible traffic cues is still very important, particularly where traffic is allowed a right-hand turn on a red light and where the audible traffic signal would have denoted safe passage in the opposite direction. If the elderly and handicapped population is trained to use the signals, then these signals must be fail-proof. Users may be seriously disoriented if the signals fail or malfunction, especially along long routes in different directions at busy intersections.

4.6 Parking and Vehicular Turning Movements

Vehicular traffic has a substantial impact on crosswalk access and safety both by volume and motorist behaviour (and misbehaviour).(31) Traffic authorities are often forced to limit pedestrian crosswalks to one side of an intersection because of the volume of vehicle turning movements. This is usually done where the capacity of the intersection would be severely reduced by introducing a pedestrian cycle or where pedestrian/vehicular conflicts have resulted in a history of accidents. The effect of this type of intersection may be a trade-off of time for improved safety of the elderly and the handicapped.

Motorists illegally parking vehicles within six metres of a crosswalk and sometimes within a crosswalk cause serious problems for those using wheelchairs. The location of wheelchair ramps offset to the curb edge, while important to the visually impaired, can be troublesome to wheelchair users when motorists park too close to the crosswalk. Such parked vehicles may obscure the view of pedestrians to motorists. At present there does not appear to be any particular way of dealing with this problem other than police enforcement.

4.7 Pedestrian Orientation

Two sets of skills are needed if elderly and handicapped persons are to successfully negotiate the urban street environment. First, they must know where things are in their environment. They must comprehend their own relationship to street architecture, building entrances, and at a larger scale, the layout of buildings and towns. This set of skills is called "orientation". Second, they must be able to travel safely from place to place. They must avoid hazards and stay on their path. This second set of skills, which is called "mobility", requires the minute-to-minute use of environmental

information that a visually-impaired person gets from a long cane, dog guide, or other mobility aid.

Orientation and mobility skills are related but distinct. For example, travelers may know where they are, but have difficulty walking a straight path. More commonly, they have good mobility skills, but poor orientation abilities. They may be able to negotiate their immediate environment with relative ease, but have little conception of their location.

A well-designed environment should support effective orientation and mobility; it should be clearly signed, free of hazards and present adequate information about location and direction.

4.8 Weather and Gradient Considerations

When designing a pedestrian crossing system for Canada-wide applications, the impact of diverse urban geography and weather conditions must be considered. In some cases only broad functional specifications can be developed. Local jurisdictions need to select materials and equipment that are appropriate to their area. For example, certain types of crosswalk delineation strips may perform better in milder climate conditions. Under conditions of severe winter weather, both traffic lane and crosswalk delineation lines may actually disappear temporarily. Similarly, equipment used in areas of extreme rainfall must be well-sealed and drained to limit water infiltration.

Crosswalk delineation strips currently in use can be hazardous to the elderly when wet. This occurs because many of the elderly, particularly women, favour a type of soft footwear with a crepe sole that slides on contact with certain plastic paints and materials used to mark crosswalks. This particular footwear accommodates a great variety of foot disabilities and is effective on most other surfaces. It is therefore most likely that the crosswalk materials will have to be changed rather than the footwear.(25)

Similar problems occur with the severe gradients that exist in many cities, particularly in inclement weather. Local solutions will need to be found to accommodate the level of space available. For example, it may not be possible for entrances and exits to wheelchair ramps to be level for the desired clearance dimensions due to grade conditions. Urban designers have attempted to overcome climatic and geographic conditions within building and street architecture. Examples are the "Plus 15" projects in Calgary where a network of second-storey crosswalks have been installed and the lower building level pedestrian concourses in downtown Montreal. These facilities benefit the majority of pedestrians, but can introduce new access problems for the handicapped because of a level change and security concerns. Such accessibility problems may include all of the physical barriers described in Section 2.4.1. Figure 4-2 (e) illustrates the currently preferred location of curb-cuts. Gradient guidelines were previously discussed in Chapter 2, Section 2.4.1.

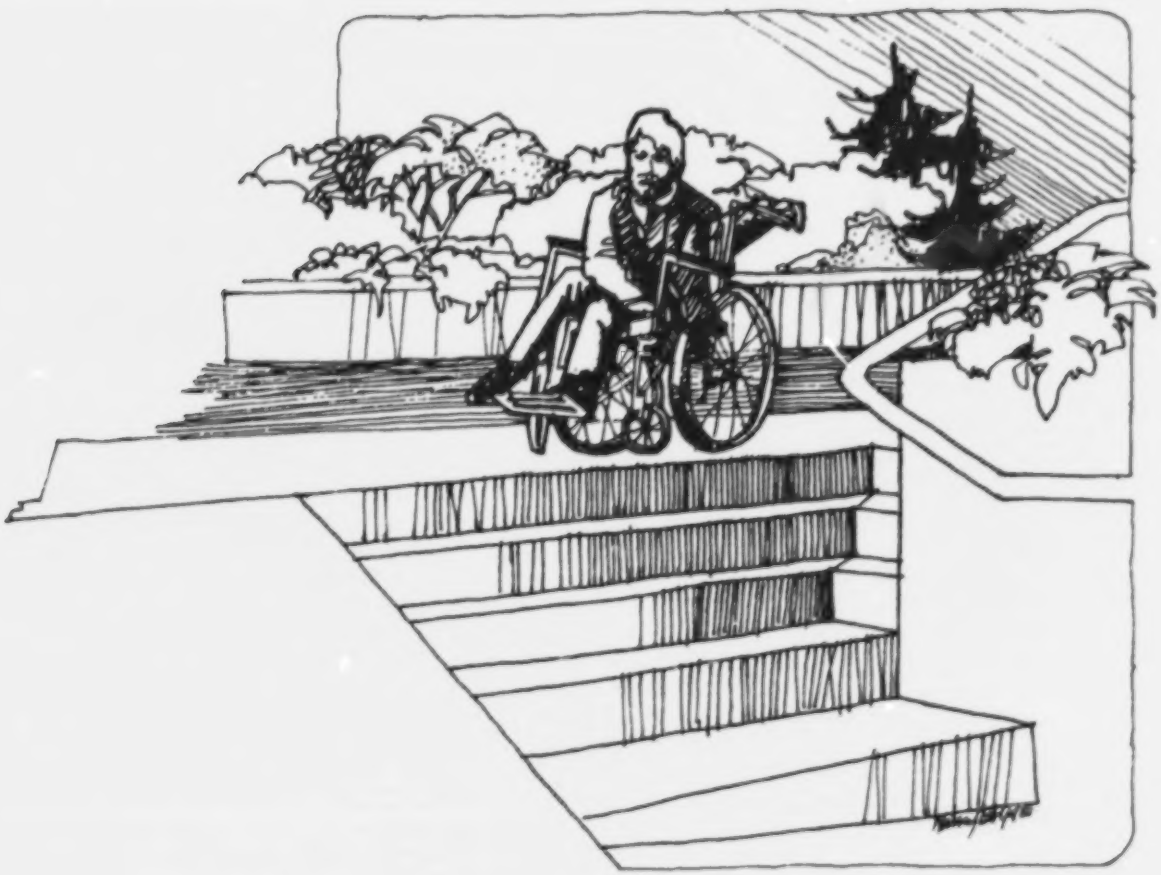

Figure 4-3 Illustrating an Architectural Barrier to Wheelchair Users (Courtesy Hickling Partners Inc.)

4.9 Maintenance Requirements

Elderly and handicapped pedestrians are at risk where there is an accumulation of leaves, ice and snow, loose gravel and other debris in the crosswalk areas. Persons using walking aids, for example, may lose their balance when the walking aid strikes loose materials.

Good design can eliminate pockets and depressions where loose materials may accumulate. Urban communities using salt/sand mixtures for icy roadway conditions should use fine-grained aggregates that have not been accidentally mixed with larger materials. While good design can help, there is no substitute for regular street and sidewalk sweeping. Wear and tear of tactile surfaces and other delineation may also be a problem. Construction of underground services may disturb the surface and replacements of special features be taken for granted.

4.10 Illumination Requirements

There is a great deal of evidence that elderly people have diminished visual abilities under low levels of illumination such as nighttime or dusk. The amount of light reaching the retina of a 60 year old is approximately one-third that which reaches the eye of a 20 year old. As a result, roadways require good illumination, particularly at intersections. In addition, contrast sensitivity is greatly reduced in the elderly, to the extent that contrast (the relative brightness of a target compared to its background) must be increased by a factor of about three for the 60 year old to see as clearly as the 20 year old. Glare is a very significant problem for the elderly, due to scattering of light inside the eye, slower adaptation to intense light sources, and slow recovery from glare. Major glare sources at night are headlights from vehicles as well as the reflection of street lights from wet roadway surfaces. The presence of glare also further reduces contrast sensitivity. Glare may also be a problem in the daytime when direct sunlight on traffic signals "washes out" the colours.(32)(33)(34) Traffic signal heads are often equipped with sun shades to help improve colour visibility.

A substantial amount of research into illumination requirements is currently underway in the United States and Canada. The Roads and Transportation Association of Canada (RTAC) has an illumination manual available entitled, "Guidelines for the Design of Roadway Lighting". Other documents are expected to be available from the Transportation Research Board in 1985 as a result of a symposium on "Providing Visibility and Visual Guidance to the Road User" held in Washington, D.C. in July 1984.

5. REVIEW OF RELEVANT POLICIES, RESEARCH AND TECHNOLOGY

Most of the developments in improved safety for the elderly and handicapped have concentrated on the needs of the visually impaired. Only very recently (since 1980) have there been significant developments in overall system and design. Chapter 5 presents an overview of current policies, research and technology relevant to improving crosswalk accessibility and safety for the elderly and handicapped pedestrian.

5.1 Systems for the Visually Impaired

This includes audible traffic signals and the related tactile cues that locate the pedestrian-activated control buttons.

5.1.1 International Experience

Experience in the following countries was obtained from a substantial literature search:

(a) Australia - Substantial experimentation with various audible traffic signal systems has been carried out since the early nineteen-sixties. The Royal Blind Society of New South Wales has been actively supporting special signal installations. A great variety of devices have been tested, including:

- tactile vibration devices tested in Adelaide and Brisbane,
- bell and buzzer signal devices tested in Sydney and Melbourne.

The most successful devices found through experimentation appear to be similar to the Japanese "touch-post" systems where a pedestrian-activated "WALK" signal emits a musical tone. Currently most systems use a "clicking" sound.(35)(36)

(b) Denmark - Audible traffic signals for visually-impaired pedestrians are becoming standard. The installations usually include the standard "WALK" and "WAIT" signals plus a guiding tone to help keep pedestrians within the crosswalks.(35)

(c) Finland - Audible signals are used extensively. As an example, there are twenty-eight (28) installations of audible traffic signals in Helsinki. These signals produce a continuous tone sound on the "WALK" cycle and a "broken" sound on the "DON'T WALK" cycle. Audible signals, manufactured locally, are installed on routes most used by the visually handicapped.(37)

(d) Japan - Japan has a national policy for the installation of special "touch-post" audible signal activators. The Japanese system of touch-posts is usually installed with special patterned pavement tiles that lead the pedestrian to the signal control button. These "Braille tiles" are readily identified by visually-impaired pedestrians wearing soft-soled footwear. The audible signal is mounted on a post facing pedestrians.(38)

(e) Norway - Audible traffic signals are used extensively. As an example, there are twenty-two (22) installations in the city of Oslo. These signals emit a continuous tone on the "GREEN" phase only. Currently, technology from Finland is being used.(39)

(f) Great Britain - Great Britain has a national policy providing for auxiliary sound signals at uncomplicated signal locations. The Department of the Environment issued a specification in 1968 for audible signals for use with "Pelican Crossings".(40) Currently the Department of Transport is experimenting with new directional audible devices and tactile indicators for use with Pelican Crossings. Experimentation with special orientation devices using male and female voices is currently being carried out in Edinburgh.(41) See Section 5.2.2 for further details on crosswalk design in Great Britain.

(g) New Zealand - New Zealand has a national policy providing for auxiliary sound signals for uncomplicated signal locations.(35)

(h) Sweden - By the year 1975 some seventy percent (70%) of urban traffic signal installations were reported to be equipped with audible facilities for the blind. A compact device for mounting within a standard pedestrian signal call-box is available at nominal cost.(42)

(i) Switzerland - In Bern, a number of devices have been installed which signal to visually-impaired pedestrians by means of a vibrating plate that it is safe to cross the street. These installations were reported to be less intrusive than previously tested acoustic signals. The vibrating plate is also the activation button for pedestrian-controlled traffic signals.(43)

(j) United States - One example of a very well-accepted system is the audible signals system installed in the City of Huntington Beach, California.(44) This system uses distinct bird-like audible signals to orient the pedestrian in the correct direction and a raised "threshold strip" at ninety degrees to the signal activator to providing a tactile locator. Numerous devices have been tested in other communities, including Salt Lake City, Utah, which has twenty (20) installations similar to those in Huntington Beach.(45)

A unique guidance system for the blind has been tested at the University of New Mexico at Albuquerque, New Mexico. This system, called "Tracks for the Blind", was developed by a professor of the school of architecture, and was installed in the Student Union Building. The system consists of a low-power AM radio transmitter connected to a series of wire antennae placed beneath floor coverings or underground. A low "humming" sound transmitted by the antennae is received by a tiny radio in the blind user's cane. An audible sound or cane vibration allows the cane user to follow the track.(46)

5.1.2 Canadian Experience

The consultant team contacted traffic engineers in all of the larger Canadian cities requesting information on special treatments of crosswalks and signals for handicapped persons. The following data was received:

(a) Calgary - Calgary has a policy of the installation of audible signals upon a request from the blind. The installations are made to meet the specific requirements of the person requesting them. Currently there are three (3) installations using a pulsing whistle signal which operates automatically with the "WALK" phase.

(b) Edmonton - Edmonton has one (1) installation at Jasper Avenue and 121 street (close to CNIB offices). This is a bell signal operated automatically with the "WALK" phase. It was installed in 1965 by the City Works Department at the request of the CNIB. The tone varies for the major and minor street crossing.

(c) Hamilton - The City of Hamilton reported one (1) installation of an audible signal adjacent to the CNIB residence building. This "beep" signal, which uses a combination of solid and intermittent tones, is mounted just below the normal traffic signal display.

(d) Lethbridge - Lethbridge is installing the Japanese type of tone signals in the Central Business District. One (1) audible signal was installed in 1983.

(e) Montreal - Two (2) audible signal installations were reported on for Montreal. These signals use a horn and buzzer. The horn alerts pedestrians of a signal change and the buzzer remains on for six (6) seconds at the beginning of the "GREEN" phase. The signal is for the major street only.

(f) Ottawa-Carleton - Ten (10) installations of audible traffic signals have been made since 1977 using a "bell and buzzer" system. The buzzer signal is used for east/west crossings and the bell for north/south crossings. The audible signals come on automatically during the "WALK" cycle only.

(g) Regina - Regina has one (1) audible signal on an arterial street located opposite the CNIB office. The warning operates on the "WALK" signal phase on the major street only.

(h) Vancouver - Vancouver has four (4) installations in total. Two of the older installations employ a "fire engine" type of siren. They are located near the former CNIB office in South Vancouver. The newer installations use an audible tone signal. One is located in a high density downtown residential area near the community centre and the other on a major arterial close to a community college. The older installations date from 1970 and were manufactured in the City Works Department. The new ones employ Japanese technology.

(i) Victoria - The City of Victoria has one audible traffic signal installation using a "beep" tone. The audible signal is automatic with the "WALK" phase.

(j) Winnipeg - One audible signal installation was reported adjacent to the CNIB offices.

(k) Smaller Cities - Audible signal installations were also reported in Brantford and in Kitchener-Waterloo.

5.2 Crosswalk Design

5.2.1 Canadian Practice

The Canadian pedestrian crossing system design practice was described in detail in Chapter 3 of this report. The Manual on Uniform Traffic Control Devices for Canada includes standards for the following:

- Traffic warning and pedestrian information signs in Part A Sections A2.13.05; A2.15, 16 and 17; A3.60 through A3.64.
- Traffic signals in Part B.
- Pavement markings Part C Sections C2.52, 53, 70 and 80.
- Safety zones Part C Section C3.21.
- Typical intersection layouts are shown in Figure C.21 and C.22.

5.2.2 The British System

Typically British cities use two types of pedestrian crossing systems: "Pelican" crossings and "Zebra" crossings.(40)(47)

(a) Pelican Crossing - This is a three-phase pedestrian-activated crossing system where pedestrians wait for a steady "GREEN MAN" signal before pushing a button to activate a red signal against the traffic. The steady "GREEN MAN" signal turns to a flashing "GREEN MAN" for a sufficient period of time for pedestrians to cross. A period of time is provided when the steady "GREEN MAN" is not displayed to ensure an adequate flow of vehicles through the crosswalk. In effect, the pedestrian is provided with an opportunity to interrupt the signal cycle without impairing the street capacity.

(b) Zebra Crossing - The Zebra crossing is simply a transverse striped pedestrian crosswalk with protective buffer zones using zig-zag stripes. Pedestrians are required to cross on the stripes, not on the zig-zag markings. This design is intended both to alert motorists of a pedestrian crosswalk and to ensure that vehicles do not encroach on the pedestrian crosswalk area itself.

5.2.3 United States Implementation Manual

The Federal Highway Administration of the United States Department of Transportation released an implementation manual for "priority accessible networks" for elderly and handicapped pedestrians in January

1980.(26) This manual was prepared by researchers at the Pedestrian Research Library of the College of Architecture at the Georgia Institute of Technology. The manual includes several guidelines not addressed in the section on crosswalk lines of the Manual of Uniform Traffic Control Devices for Canada. The following is a summary of the supplementary recommended practices for good crosswalk design from the United States document.

(a) Angled Crosswalks - Wherever possible, avoid oblique angle crosswalks. If, because of the layout of the streets, an oblique angled crosswalk is necessary, then at least one of the marking lines should be retained at 90 degrees to the curb, where this is practical.

Where oblique angled crosswalks must be used, the pavement markings indicating the edges of the crosswalk should be detectable to the visually impaired using long cane techniques.

(b) Visual Obstructions - Avoid locating crosswalks where they are hidden from the view of drivers.

Avoid locating street furniture, poles, mail boxes, telephone boxes, etc. on the sidewalk close to the crosswalk where they may hide pedestrians from view.

Avoid locating crosswalks where entering pedestrians may be hidden from view by trees, planters and other planting materials.

(c) Parking Conflicts - Except where sidewalk extensions are provided, parking should not be permitted within 6 m of the nearest crosswalk. At signalized intersections, parking should not be permitted within 9 m of the nearest crosswalk at the intersection.

On streets where legal parking is permitted at all times, pedestrian visibility can be improved by extending that part of the sidewalk that adjoins the crosswalk out to the edge of the parking lane. (This can also reduce pedestrian crossing time.)

(d) Crosswalk Dimensions - Crosswalk width should be based on calculated pedestrian volumes. A width of 3.0 m is preferred. (The Canadian standard is a minimum of 2.5 m.)

Where there is likely to be a considerable amount of elderly and handicapped pedestrian traffic, and heavy volumes of vehicular traffic, the crosswalk length should be not greater than 23 m without providing a refuge island.

(e) Signal Timing - An acceptable crosswalk length will depend, not only on the distance to be travelled, but also on the time allotted by the traffic signals. Traffic signal timing should be calculated to take into account the needs of the elderly and handicapped pedestrian.

Wherever possible, reduce the length of the crosswalk by extending the sidewalk out to the edge of the parking lane, as in (c) above.

(f) Crosswalk Markings - For added visibility the area of the crosswalk may be marked with diagonal lines at a 45° angle or with transverse lines at a 90° angle to the line of the crosswalk. These lines should be 30 to 60 cm wide and spaced 30 to 60 cm apart. When the diagonal or transverse lines are used, the longitudinal lines may be omitted. (This is not permitted in the Canadian standard.)

Crosswalk markings should present a slip-resistant surface for pedestrians. For crosswalk surfaces, avoid the use of brick paving or other materials in small units with many joints. The boundary lines of crosswalks should be made detectable to the visually handicapped.

(g) Orientation Clues - Special consideration for the needs of the visually impaired and the mobility techniques that they use must be considered at the beginning and end of crosswalks.

(h) High Volume Crosswalks - At crosswalks where there is substantial pedestrian traffic, sufficient waiting space should be provided, where this is possible.

(i) Hazards - Wherever possible, manholes, gratings and other access covers should not be located within crosswalks. If this cannot be avoided, then they should be made easily visible and slip resistant.

5.3 Urban Design Guidelines

5.3.1 Street Architecture

The Australian government recently developed a draft standard on architectural accessibility for disabled persons which includes provisions for external as well as internal building access. This standard, known as "The Australian Standard for Design for Access by Disabled People" was issued in draft form in May 1983. The draft standard was subsequently reviewed by national associations for the visually impaired through a survey of Australian user groups conducted by the University of Melbourne.(49) The principal recommendations of the user groups regarding those sections of the draft standard pertaining to walkways, crosswalks and street architecture were as follows:

(a) Use of Colour and Lighting - The use of colour to differentiate aspects of the environment is by far the most important aid for the visually impaired. Lighting is very important to more than two-thirds of the legally blind.

(b) Walkways and Wheelchair Ramps

- That the camber (arc) of crowned or banked walkways and ramps should not exceed one in fifty, in cross section.
- That in addition to textural changes on either side of a walkway, the edge of the path should also be of a colour in contrast to the path.

- That the difference in level between the adjacent ground and the path should be less than 12 mm.
- That the edges of the path should be level or slope slightly upward away from the path.
- That a minimum footpath width of 1000 mm should be provided beyond the top of a wheelchair ramp.
- That wheelchair ramps should not be placed on a diagonal, but lead directly to the opposite side of the street.

(c) Tactile Cues - That wherever walkways or wheelchair ramps join other walkways, ramps, driveways or parking areas, the transition should be indicated by a texture change of not less than 300 mm wide.

(d) Projections - That street furniture, stair balconies, branches and other obstacles should not protrude into the walkway area more than 125 mm (preferably not at all).

(e) Control Buttons - Control buttons should be of a colour in contrast to the surroundings.

5.3.2 Architectural Guidelines Manuals

Most building codes regulate only the design of internal facilities for the handicapped. During the literature search for relevant documents, the consultants found two architectural guideline manuals that dealt with external walkways.

(a) Crossing Structures Manual - The Federal Highway Administration of the United States Department of Transportation has recently disseminated an implementation manual on making crossing structures more accessible to the elderly and the handicapped. This manual, entitled "Guidelines for Making Pedestrian Crossing Structures Accessible", was published in August 1984.(49) The guidelines, which were based on research work carried out at the Georgia Institute of Technology, are not intended as standards, but rather good practices for designers. Many of the guidelines in this manual apply to off-structure walks as well as to those for below-grade or overhead walkways. Table 5.1 has been extracted from the above publication because the consultant team were of the opinion that this summary of "Recommended Design Features for Accessibility" represents excellent guidelines applicable to crosswalk design in general.(51)

(b) Manual of Design for the Visually Handicapped - The Ministry of Community and Social Services of the Government of Ontario published a general architectural guidelines manual in 1978.(52) The manual, entitled "Guidelines - Designing for Visually Handicapped", includes references to external planning problems. Guidelines are provided for walkway surfaces, avoiding obstacles, outdoor furniture placement and special treatment of street crossings. The guidelines are similar to others reviewed in Sections 5.3.1 and 5.3.2 (a).

DESIGN FEATURES	REASON FOR PROVIDING
Stopping or resting places (landings)	Elderly and handicapped pedestrians lack stamina and strength.
Detectable warning cues (clues - term used in United States)	Blind persons need to be alerted to potential hazards such as stairs, intersections, driveways, etc.
Detectable guidance cues (clues)	Where the natural cues (clues) are not available, supplementing guidance cues are useful.
Protection from low projections	Overhead projections avoided by sighted persons are hazardous to visually-impaired pedestrians.
Tactile signs	Route layout signs for visually-impaired pedestrians are needed for guidance.
Large legend signs	Handicapped persons with limited vision can often read signs if the letters are large.
Ramps with moderate grades	Handicapped persons in wheelchairs can utilize over- or undercrossings if ramp access is provided.
Non heat-conducting handrails	Some elderly and handicapped persons are dependent on handrails and may be injured because of a high sensitivity to heat or cold.
Dual access facilities (steps and ramps)	Handicapped persons on crutches or using canes often find stairs easier to negotiate than ramps.
Wide walkways	Plenty of travel room encourages movement by elderly and handicapped pedestrians.
Stable slip-resistant surfaces	Elderly and handicapped pedestrians are not agile and need good footing for confidence. Wheelchairs on ramps need slip resistance.
Signs located within pedestrians' normal vision	Signs mounted the standard height may be missed by pedestrians in wheelchairs or elderly pedestrians with stooped stature.
Area lighting	Persons with poor eyesight require well lighted areas to recognize landmarks, signs and other guidance features.

Table 5.1 Recommended Design Features for Accessibility

5.4 Signal Programming

Two examples of variations in signal programming were found during the review of current Canadian traffic engineering technology. These were found in Calgary, Alberta, and in Brandon, Manitoba.

In Calgary, in certain cases, pedestrian signal clearance intervals are lengthened to match the time required for elderly or "encumbered" persons to cross the street. Normally the timing is established using a 1.2 m/second walking speed for a pedestrian to cross the street. When significant numbers of elderly or handicapped persons use the crossing, the timing is extended to accommodate walking speeds of about 0.9 m/second.

In Brandon, the introduction of new solid state traffic signal controllers has allowed the City Engineer to incorporate a four (4) second warning flash phase within the "DON'T WALK" period. This is to alert pedestrians that there may not be sufficient time to cross the street so they will wait for the next full cycle. Since this variation in the signal programming is not a current standard in Manitoba, approval is being sought from the Manitoba Highway Traffic Board.

One technique, which is being investigated in depth in Great Britain by the Traffic Control and Communications Division of the Department of Transport, is to equip all disabled persons with a small biscuit-sized transponder which would allow an equipment on the pedestrian crossing to recognize the presence of a disabled person wishing to cross the road and which would then automatically lengthen the crossing period.(53)

5.5 Deficiencies

An analysis was made of current technology in view of the needs of the elderly and disabled as described in Chapter 2 of this report. The deficiencies, primarily in Canadian approaches to design, are described in the following sections under headings developed as the "needs criteria" in Section 2.5 of Chapter 2.

5.5.1 Adequate Time

With the exception of the two examples described in Section 5.4 of this chapter, the consultants were not able to find any significant studies or applications of altered and/or extended signal programming. The techniques currently used are to eliminate vehicle left-turning movements, particularly during peak periods, and to encourage pedestrians to wait for an initial "WALK" phase before proceeding. Proposed techniques include physically extending sidewalks to reduce walking distances and the installation of median refuges (Section 5.3). The consultants are of the opinion that with the improved capability of solid state programmable signals, the potential for varying the signal timing warrants substantial investigation.

Typical current design standards for urban streets result in crossing widths ranging from about eighteen (18) metres for local streets and arterials to twenty-six (26) metres for six-lane urban highways. Crossing speeds of able-bodied pedestrians range from about 1.0 metre per second up to about 1.4 metres per second for pedestrians crossing in large groups.(54) Most traffic signals are set for an average crossing speed of about 1.2 metres per second. This speed translates into typical crossing times of from fifteen (15) to twenty-two (22) seconds. Studies of the needs of the elderly in Sweden showed that a walking speed of 0.9 metre per second would accommodate most needs and a speed of 0.6 metre per second would accommodate all but the very slowest.(55) These speeds translate into average crossing times of about thirty (30) seconds.

5.5.2 Barrier-Free Design

It was apparent from the volume of literature available dealing with this aspect of urban design that the needs are well understood from the point of view of urban design. The deficiencies are that external design is not generally mandated in building codes, placement of obstacles occurs subsequent to the construction, and maintenance of walkways is often less than that desired by the users.

5.5.3 Orientation

The physical orientation needs of visually-impaired persons do not appear to be well understood. Current standards for crosswalk design do not adequately deal with intersections that are not constructed at right angles. An illustration of the treatment of such an intersection in the Manual of Uniform Traffic Control Devices for Canada shown previously in Figure 3-1 does not appear to conform to the preferred layout as described in Section 5.2.2 (a) for example. Good examples exist, internationally, of the use of tactile clues to orient visually-impaired pedestrians. At present in Canada, the aids to orientation used in connection with traffic signals are mainly the audible signals described in Section 5.1.2.

5.5.4 Information

Currently most information regarding the status of traffic signals is imparted visually. The red signal is always located at the topmost position or on the left side in the case of a horizontal signal mounting. Similarly, the "DON'T WALK" signal is mounted above the "WALK" signal. This allows some visually-impaired persons to know what the signal status is when the colour or pedestrian graphic symbol is not perceived. The use of shapes other than a circle for the signal heads is not currently being contemplated. The use of audible signals to supplement visual information is increasing slowly. Warrants do not exist for such installations in Canada. The use of other technology such as broadcast signals for those who are both hearing and visually impaired is not apparently being investigated for outdoor applications.

5.5.5 Education

A substantial investment in numerous pedestrian safety programs has been made throughout Canada for the benefit of children using the street system. Many of these safety programs are associated with getting children to and from school safely, but most also include general pedestrian safety instruction. Instruction in pedestrian safety is often provided within the schools by the traffic safety officers from local police agencies. Other agencies and institutions such as the Canadian Automobile Association (CAA), the Canada Safety Council, and a variety of local service clubs also provide resources. Examples of recent educational activities include the "point your way to safety campaign" and the "Elmer, the safety elephant" program.

Since the accident frequency of older persons is similar to that of children, the obvious question asked by the consultant team and other researchers was "what aspects of the child pedestrian safety programs, if any, could be useful in designing education programs for the elderly and the handicapped?"

Another area requiring substantial attention is that of educating the motorists to the type of disabilities that affect the mobility of elderly and handicapped pedestrians. Many of these disabilities are not obvious to the motorist, who may become impatient with a pedestrian who appears to be deliberately slow in crossing the street. An understanding of these needs would help motorists display the care and tolerance that is afforded to the more visible handicapped population using walking aids and wheelchairs.

6. ANALYSIS OF POTENTIAL IMPROVEMENTS

Chapter 6 describes the analysis of potential improvements in pedestrian crosswalk systems through the application of existing and new technology and resources described in Chapter 5. The analysis is based on the premise that crosswalk system improvements currently being implemented by several municipal traffic jurisdictions will continue to gain acceptance, albeit not as quickly as some user advocate groups would like. The foregoing premise is taken as the "neutral path" condition from which the impacts of interventions in urban design, new crosswalk system technology, and the application of community resources are measured.

The analysis of existing crosswalk systems and potential improvements was based on the user needs criteria developed in Chapter 2 for the various application conditions described.

In reviewing innovations in pedestrian crosswalk systems and signal technology of particular benefit to the elderly and handicapped, it is important to understand the environment in which the technology will be applied. For example, technology such as talking bus stops and audible traffic signals may work satisfactorily in the quieter suburban areas, but may not work as well in the busy and noisy streets in the downtown areas of most cities. Understanding the accident locations and frequencies for the elderly and the handicapped is also important.

6.1 Analysis of Potential Applications by Need

The potential applications for improved crosswalk systems and signal technology were previously discussed in Section 3.6 of Chapter 3. The application classifications were as follows:

- CBD CONDITIONS (including all high volume centralized activity centres).
- AUTO DOMINANT conditions (such as are found on major arterial and collector streets).
- PEDESTRIAN DOMINANT conditions (typical of local activity centres).
- RURAL CONDITIONS (where activities are widely dispersed).

Before potential improvements in the pedestrian crosswalk systems and signal technology can be assessed, it is necessary to understand where the majority of accidents are occurring.

6.1.1 Relationships of Accidents to Housing Locations

Two important findings are emerging from housing and accident statistics for the elderly:

- A majority of elderly persons living in urban areas tend to be concentrated close to arterial streets. This is

partly due to the common practice of developing institutional housing on low-cost land, but also due to the aging of neighbourhoods (particularly those close to the CBD) and subsequent construction of major arterials.
- While trip-making by the elderly is proportionately less than for the general population, a higher proportion of trips are made within the vicinity of their residence as pedestrians.(56)

Studies of the trip-making behavior of elderly pedestrians in a variety of developed and less developed countries indicate a common pattern. For example, a recent study by researchers at the Transportation Research Institute of the Technion - Israel Institute of Technology in Haifa (57) found that:

- traffic accidents involving elderly people occurred mainly within walking distance of their homes;
- their homes were located nearer to the city centre and along arterials to a greater extent than other population groups;
- they walk a great deal near their homes, i.e. in streets with above average traffic volumes;
- their knowledge of traffic was extremely poor, particularly among those who had never been drivers and those whose knowledge of the (Hebrew) language was poor.

Similar studies conducted in other countries reported that:

- mobility of the elderly is dependent upon an individual's judgement on their walking difficulty and sight problems rather than overall health;
- only the most severe difficulties result in a decrease of mobility within the neighbourhood;
- mobility outside the neighbourhood decreases with increasing sight and walking difficulties;
- a decrease of mobility outside of the immediate neighborhood results from a shortening of trip lengths rather than a lowering of the frequency of going out.

The pedestrian accident statistics for the elderly reveal that:

- a large percent of the accidents (43%) occur at intersections (21% where traffic signals exist);(3)
- auto-dominant arterial streets present the most serious hazard.(58)

6.1.2 Accident Exposure Rates

Because the high rate of pedestrian traffic accidents among the elderly is an international phenomenon, several researchers have attempted to find common factors to explain the incidence. Some agencies have investigated the degree of risk or exposure, suggesting that the elderly may be involved in more accidents because they engage in more pedestrian activity. These investigations have concluded that the elderly have a disproportionate number of accidents based on exposure rates using such criteria as roads crossed, distance walked and hours spent in walking.(59)(60)

6.1.3 Neutral Path Conditions

The user needs criteria developed in Section 2.5 of Chapter 2 were used to evaluate existing technology and the potential for improvements to existing crosswalk systems for each of the application conditions described. Table 6.1 presents a summary of the analysis of existing systems, technology and resources. The following sub-sections provide background on the analysis of a "neutral path" condition from which further improvements may be evaluated. (See note on page 44.)

(a) Adequate Time - Improvements could be achieved under CBD conditions by using the technique being used in Calgary, Alberta, of extending the traffic signal cycles where feasible. Auto-dominant intersections may require restricted turning movements; pedestrian-dominant intersections may require pedestrian-activated crosswalk signals, and the lower density "rural type" crosswalks may simply require additional identification and signing.

(b) Barrier-Free Design - This can only be achieved under CBD conditions where redevelopment is taking place or street architecture is being redesigned and/or rebuilt. The best current solution to auto-dominant conditions is grade-separated crosswalks designed for the handicapped, however many local recreational needs can be met by eliminating, where possible, the necessity of crossing major arterials. This may require a design of neighbourhood pathways that do not need to cross auto-dominant streets. Where pedestrian volumes are dominant, improved wheelchair ramp designs are possible, and in low density "rural" areas, signing the most accessible crosswalks and routes may be the most effective way to remove barriers to mobility.

(c) Proper Orientation - Visually-handicapped pedestrians as well as those who are confused or affected by psycho-motor slowing use vehicle noise levels and traffic movement as orientation aids. Such persons are often assisted by the flow of other pedestrians in a pedestrian-dominant situation. Rural conditions present the greatest challenge since the flow of both vehicles and pedestrians is intermittent and few persons are available for advice. For crosswalks serving residence locations under these low-density conditions, improved signing and additional mobility training aids and resource persons may be required.

(d) Accurate Information - A continuing use of audible signals for special applications in the CBD and for pedestrian-dominant crosswalks is likely. No warrants exist at present for auto-dominant conditions, however some audible signals have been installed under these conditions on an ad hoc basis. Installations under rural conditions are not currently the policy either nationally or internationally.

(e) Ease of Education and Training - At present occupational therapists provide most of the institutional training. Residential institutions may provide some additional training aids, particularly if located in isolated low-density and rural areas.

	APPLICATION CONDITIONS			
	CBD CONDITIONS	AUTO DOMINANT	PEDESTRIAN DOMINANT	RURAL CONDITIONS
USER NEEDS				
ADEQUATE	Extend signal cycles	Restrict turning movements	Pedestrian activated crosswalks	More crosswalk identification
BARRIER-FREE Design	Re-design architecture	Grade-separated walkways	Better W.C. ramp designs	Sign route
Proper ORIENTATION	(Assisted by noise levels)	(Assisted by traffic volumes)	(Assisted by other pedestrians)	More training aids
Accurate INFORMATION	Improve visuals; audible signals	Improve visuals	Audible signals	Improve visuals
Ease of EDUCATION (Training)	Occupational Therapists	Occupational Therapists	Occupational Therapists	Residential institutions

Table 6.1 Existing Systems, Technology and Resources

Neutral Path Conditions: The above table presents a summary of an analysis of the anticipated future response to user needs based on existing systems, technology, and resources. This represents "neutral path conditions" from which the potential for the application of new systems and technology and/or a more intensive use of resources was assessed.

6.1.4 Potential for Improvement to Existing Systems

With due consideration for the impact of housing locations (described in Sub-Section 6.1.1), the consultant team evaluated the potential for a departure from the neutral path conditions described above. To facilitate this evaluation, a workshop was conducted in mid October, 1984, at the Gerontology Resource Centre at Simon Fraser University in Greater Vancouver. The participants in this workshop included the full multi-disciplinary study team who approached the analysis from a broad perspective. Table 6.2 on page 46 presents a summary of the analysis of the potential for change to existing crosswalk systems. The following sub-sections provide a discussion of the analysis of good, fair, and poor opportunities for change.

(a) Adequate Time - Pedestrian-dominant situations are rated "good" for potential changes due to existing precedents and the obvious, if not statutory, warrants. Rural conditions rated a "good" simply because it is feasible to preempt the right-of-way of infrequent vehicular traffic. Under higher volume traffic conditions, the potential for improvement with current policies and technology is only "fair".

(b) Barrier-Free Design - Pedestrian-dominant conditions are rated "good" for the same reasons as described in (a) above. The CBD conditions were rated "poor" because of congestion (lack of space) and the high cost of redevelopment. The auto-dominant conditions were rated "fair" because of the high cost of grade-separated crosswalks and the rural conditions "fair" because of the limited numbers of users.

(c) Proper Orientation - The first three application conditions were rated "good" because of the potential spin-offs from audible signal applications and the patterning effect of well-designed crosswalk systems. The rural conditions rated a "poor" due to the difficulty of improving orientation in isolated areas.

(d) Accurate Information - Audible signals are not expected to be as effective under CBD conditions and will likely continue to be "poor" for the hearing impaired. The potential for improvements in auto-dominant conditions is only "fair" under current policies in Canada. Pedestrian-dominant conditions will likely continue to be the warrant for audible signals. The rural conditions were rated "poor" for the same reasons as discussed in (c) above.

(e) Ease of Education and Training - It is relatively easy to train elderly and handicapped pedestrians to move under CBD and pedestrian-dominant conditions. It is difficult to train pedestrians in an auto-dominant environment, and even more difficult to educate motorists! Hence the "fair" rating for auto-dominant conditions. The potential for training at residence institutions located in low-density or rural conditions is also rated "good".

	APPLICATION CONDITIONS			
	CBD CONDITIONS	AUTO DOMINANT	PEDESTRIAN DOMINANT	RURAL CONDITIONS
USER NEEDS				
ADEQUATE TIME	Fair (Restrict left turns)	Fair (Restrict left turns)	Good	Good
BARRIER-FREE Design	Poor	Fair	Good	Fair
Proper ORIENTATION	Good	Good	Good	Poor
Accurate INFORMATION	Poor (For hearing impaired)	Fair	Good	Poor
Ease of EDUCATION (Training)	Good	Fair (Educate motorists)	Good	Good

Table 6.2 Potential for Improvements to Existing Systems

6.2 Evaluation of New Technology and Resources

During the evaluation workshop, the consultant team also reviewed and subsequently evaluated the new technology and additional resources that could be applied to improve pedestrian crosswalk systems. Table 6.3 (page 48) presents a summary of the analysis of new technology and resources by application condition for each of the user needs criteria.

6.2.1 New Technology

The definition of "new technology" included all hardware and software that was not likely to be applied in the near future without some outside stimulus or intervention. The definition implies a departure from the neutral path conditions described in Section 6.1. This new technology is described in the following sub-sections:

(a) Signal Programs - Currently, the older mechanical traffic controllers are being replaced with solid state programmable controllers. Some major cities such as Toronto have installed computer controlled traffic signal networks. Smaller versions of such networks are currently being considered for cities such as Vancouver, for example. Such systems may have the capability of accommodating the preemption of some "GREEN" time allocated to vehicles for the benefit of pedestrians on a cyclical basis providing that such programs are developed. There is an opportunity to both extend signal cycles and vary signal programs if the necessary research and development is carried out.

(b) Tactile and Audible Locators - Tactile and audible locators have been tested internationally but have not yet been introduced to Canada. This technology has the potential to improve pedestrian orientation.

(c) Graphic Displays and Markings - The current design standards for traffic signals and crosswalk lines may be able to incorporate higher intensity markings and displays in addition to the minimum requirements.

(d) Pedestrian Information Systems - Pedestrian information systems for the communication impaired have been investigated in substantial depth by researchers at the Transportation Development Centre (TDC) of Transport Canada.(61) Those systems that have the potential for use in connection with traffic signals include "loop systems" and talking signs.

The loop system is a simple broadcast system that requires a buried wire loop to which audio information will be transmitted via an amplifier. The pedestrian interfaces with the system by means of a hearing-aid microphone which can sense and convert to audio the magnetic field radiated by the buried loop. The physical installation would be similar to magnetic loop buried in the pavement of a street that can activate traffic signals when a vehicle crosses the loop.

	APPLICATION CONDITIONS			
	CBD CONDITIONS	AUTO DOMINANT	PEDESTRIAN DOMINANT	RURAL CONDITIONS
USER NEEDS				
ADEQUATE TIME	Extend cycles	Vary cycle program	Extend cycles	Extend cycles
BARRIER-FREE Design	Extend building codes	Improve pedestrian access	Establish design standards for cross-walks	Design standards
Proper ORIENTATION	Tactile locators	Tactile locators	Audible locators	Additional graphics
Accurate INFORMATION	Audible signals where feasible	Audible signals	Audible signals	Increase intensity of infor-tion
Ease of EDUCATION (Training)	Training aids	Training aids	Training programs for activity centres	Training programs for resi-dences

Table 6.3 Potential New Technology and Resources

A supplementary, potential message reinforcing technology for the visually impaired which would supplement visual signs is that of talking lights. This system requires the pedestrian to aim a receiver at an infra red light beam transmitter adjacent to a sign. The light beam is picked up by the receiver and converted back into auditory form. Because the system has a transmission range of hundreds of feet, the traveller using it could obtain information from distant information signs.(62)

6.2.2 Other Resources

In addition to applications of new technology, the more intensive use of resources would have a substantial impact on crosswalk system design and pedestrian safety. The potential additional resources identified by the consultant team in this study are described in the following sub-sections.

(a) Building Codes - Existing building codes could incorporate external design standards. Since most developers of major buildings are responsible for reconstructing the sidewalks and other pedestrian areas, a barrier-free design both externally and internally could be achieved.

(b) Design Standards - The existing standards for traffic signals and crosswalk lines could be supplemented by design standards based on the guidelines described in Section 5.3 of Chapter 5 of this report.

(c) Audible Signals - A greater use of audible signals could be stimulated in a number of ways. These could include inducements for local manufacture, resulting from the establishment of warrants and standards and a demonstration of the most effective technology.

(d) Education Program - The development of training aids and educational programs similar to those used in other traffic safety programs would likely have a significant impact on overall pedestrian safety.

6.3 Potential Benefits from New Technology and Resources

The potential benefits from the application of new technology and institutional resources are both social and economic. The major benefits are derived from improved safety for all pedestrians which has both social and economic consequences. For purposes of analysis the potential benefits were classified as reduced accidents, other social benefits and potential economic benefits.

6.3.1 Reduced Accidents

A review of the pedestrian accident statistics was necessary to gain an understanding of the potential benefits.(63) Accident statistics derived from Canadian and United States data sources are shown in Table 6.4 on page 50.(1)(2)(3)(4)

RATES FOR THE TOTAL POPULATION (1982)	
Total fatality rate for all types of accidents:	48/100,000 persons (U.S.A. - 1979)
Motor vehicle accident fatality rate:	17/100,000 persons
Pedestrian fatality rate:	2.7/100,000 persons
RATES FOR CHILDREN (For comparison - under age 15)	
Pedestrian fatality rate:	2.6/100,000 persons
RATES FOR THE ELDERLY	
Motor vehicle accident fatality rate:	18/100,000 persons
Pedestrian fatality rate:	7.3/100,000 persons
Pedestrian injury rate:	30/100,000 persons (U.S.A. rate)*
Total injuries and fatalities:	37 accidents/100,000 persons
Portion of total injuries and fatalities occurring at intersections (43%):	16 accidents/100,000 persons
Portion of total injuries and fatalities occurring with traffic signals:	8 accidents/100,000 persons

Table 6-4 Estimated Annual Pedestrian Accident Rates for Canada (based on Canadian sources and U.S.A. data where noted, per 100,000 of population)

* United States (U.S.A.) rates are for temporary and permanent disabling accidents only. Canadian data includes all reported injuries no matter how minor.

The potential for reduced accidents was analyzed for the four application conditions and applying the user needs criteria. A summary of the analysis is presented in Table 6.5. A discussion of the benefits by application condition is discussed in the following sub-sections.

(a) CBD Conditions - The potential safety benefits from applications of new technology providing barrier-free design are indicated to be the highest under CBD conditions. The reason for this is that conflicts with street architecture may result in injuries over and above those created by pedestrian/vehicle conflicts. Improvements in crossing time and accurate information are indicated to be less effective due to congestion and smaller numbers of elderly and handicapped persons in the CBD areas.

(b) Auto-Dominant Conditions - These conditions, typical of major arterial and collector streets acting as residential barriers, indicated the greatest potential benefits for improved safety through better crosswalk design.

(c) Pedestrian-Dominant Conditions - The potential to improve on the safety of access to major pedestrian activity centres ranges from low for orientation due to good existing conditions to high for improvements in time and in applying educational safety programs. Improvements in barrier-free design and more accurate information through the use of audible signals indicated modest safety benefits.

(d) Rural Conditions - Medium safety benefits were indicated for proper orientation and accurate information because although the pedestrian volumes are low, these needs are the most troublesome.

6.3.2 Other Social Benefits

The foregoing chapters of the report should not mislead the reader about the vigorous life of the elderly. The stereotype of an elderly person struggling along the street with a cane more aptly depicts a small portion who have limited mobility - the handicapped. In fact, the great majority of elderly persons are very mobile. According to the 1981 census 11 percent are still employed. Recent studies have indicated that:

- 82% had few limitations of mobility;
- 62% of those non-institutionalized had no limitations of major activities.(64)

This means that accidents may be particularly tragic both because the survival rates are lower for the elderly (compared to the average) when injured in a traffic accident, and because their future mobility and activities may be severely curtailed.

The social benefits of improving the safety of crosswalks would accrue to the whole community. The perception of improved design would provide feelings of confidence and well-being, improving the general quality of the pedestrian environment.

	APPLICATION CONDITIONS			
	CBD CONDITIONS	AUTO DOMINANT	PEDESTRIAN DOMINANT	RURAL CONDITIONS
USER NEEDS				
ADEQUATE TIME	Medium	High	High	Low
BARRIER-FREE Design	High	High	Medium	Low
Proper ORIENTATION	Low	Medium	Low	Medium
Accurate INFORMATION	Medium	High	Medium	Medium
Ease of EDUCATION (Training)	Medium	Medium	High	Low

Table 6.5 Potential Safety Benefits from New Technology

6.3.3 Potential Economic Benefits

Government policies are usually formulated on the principles of equity and efficiency. In this case, equity implies the distribution of benefits to the elderly and handicapped. Such a principle need not necessarily make the elderly and handicapped better off than anyone else, but the distribution of social benefits to the elderly and handicapped should enable them to attain at least the same mobility as anyone else. The economic benefits would be indirect in the form of a lower cost for accidents in terms of medical, traffic, legal, police and rehabilitation costs.

There is relatively little data which specifically pinpoints legal costs associated with pedestrian accidents among the elderly and handicapped. Typically the data is not broken down into such specific categories. The death due to a traffic accident of an elderly or handicapped person is usually "cheaper" than that of others, in terms of likely litigation against a municipality. The reason is that the elderly person typically has retired and no longer works, or at least has only a few years left to work, and the amount of salary foregone because of a death or injury is a major consideration in settling such legal cases. A surviving spouse may claim loss of pension from the person killed if this is relevant, but that usually does not amount to a great deal. The elderly also are less likely to have dependants, a consideration in determining legal settlements. Medical costs are probably greater for the elderly, since they take longer to heal and are likely to sustain greater severity of injuries in an accident.

The analysis therefore concentrated on government policy and its "cost effectiveness". Government policy, in this case, was assumed to be to provide safe movements for the elderly and handicapped. This could take two forms: to regulate, or to provide funding. There are basic differences in the two approaches. To regulate implies that there is a consumer failure and that there is no trade-off for the life and comfort of the elderly and handicapped. A related example is the need for seatbelt legislation. The provision of funding assumes an economic return based on reduced accidents.

The average cost of pedestrian accidents was derived from "A Manual on User Benefit Analysis of Highway and Bus Transit Improvements" published by the American Association of State Highway Traffic Officials.(65) The cost of a pedestrian accident was calculated by multiplying the proportions of fatalities and injuries by their representative costs and averaging the sum of the products. Based on a calculation made in 1981 United States dollars of $22,953 per pedestrian accident,(5) the equivalent cost in Canada in 1984 was estimated to be about $30,000 per accident. Based on a population of 2.36 million elderly plus 0.6 million handicapped persons under 65 (6), the total national cost of traffic accidents to elderly and handicapped pedestrians at urban crosswalks in Canada is estimated to be approximately 14 million dollars annually. This does not include the costs of non-traffic pedestrian accidents such as falls and injuries resulting from bad urban design or the lack of proper maintenance.

6.4 Overcoming Institutional Constraints

The following discussion of constraints applies to the institutional environment in which new traffic signals are to be implemented. It is assumed that the technology and hardware exist, and that there is a general agreement that such signals are beneficial to the users.

6.4.1 Regulation

Most of the special new technology for the improvement of crosswalk systems for the elderly and the handicapped has been developed during the past decade. Guidelines for urban design for this special clientele are even more recent. It should therefore not be surprising that the 1976 edition of the Manual of Uniform Traffic Control Devices for Canada is silent on the needs of the elderly and the handicapped. (A sub-section is now being prepared on audible signals.)(66) The production of the original manual of Uniform Traffic Control Devices for Canada was a long and cumbersome process of achieving consensus by institutions, consultants and governments at several levels. Any changes would be subject to the same slow process. It could be initially faster for municipal governmnents to implement minor improvements that are not in conflict with existing standards. This is not to suggest that municipal engineers design their own crosswalk systems, but rather that auxiliary signal systems, safety techniques and signing be used that are not in conflict with the existing guidelines. Many of the improvements described in Chapter 5 go beyond the minimum practice as set forth in the manual and would be subject to legal interpretations in the event of subsequent accidents.

6.4.2 Manufacture

At present, Canadian firms manufacturing traffic signal technology are producing equipment for standard applications only. The traffic control systems being manufactured in Canada incorporate the latest "high-tech" programmable controllers with a potential capability far beyond that which is standard practice in the mid-size and smaller urban communities. Auxiliary equipment producing audible signals for visually-impaired pedestrians is being imported by Canadian suppliers.

The potential for manufacture of audible signals and related technology in Canada is related to the size of the market. At present, while there are a number of obsolete "homemade" installations of audible signals in Canada that should be replaced, with about thirty (30) units in service, the market is very small. The potential for volume manufacture of new traffic signal technology in Canada is dependent upon standardization of the technology.

6.4.3 Implementation

The current number of installations of conventional traffic signals in Canada is estimated as follows:

- Large urban communities including Metro Toronto, Montreal and Greater Vancouver (about one per 1,500 in population)	4,000
- Mid-sized urban communities including Calgary, Edmonton, Winnipeg, Ottawa/Carleton, Mississauga, Hamilton, Laval, Kitchener/Waterloo and London	3,000
- Other urban communities of less than 200,000 in population	3,000
Total urban signal installations	10,000

The range of potential implementation of audible signals is illustrated by overseas experience. In Adelaide, for example, 3% of the traffic signals are equipped with audio and tactile units; whereas in the urban areas of Sweden some 70% of the traffic signals were reported to be equipped with audible signals. In Helsinki and Oslo, the ratio of audible signal installations is about one per 20,000 of population. Based on an estimated 10,000 traffic signals installed in Canada, the near-term potential for audible signals would appear to range from about 300 units (Australian practice) to about 750 based on Helsinki and Oslo. In the long term, with wide acceptance of audible signals as a standard, the potential could be much larger.(36)(37)(39)

7. CONCLUSIONS

Most of the needs of elderly and handicapped pedestrians can be met by improving the accessibility of urban crosswalk systems for the benefit of all pedestrians. The more specific needs of handicapped pedestrians with particular dysfunctions, such as the visually impaired for example, can be met by applying special technology developed for the purpose. Current deficiencies in crosswalk systems which impact upon the safety of all pedestrians can be overcome by better urban design. The key elements in overcoming both accessibility and safety deficiencies in urban crosswalk systems are the following:

- the national, provincial and local building codes;
- the Manual of Uniform Traffic Control Devices for Canada;
- national standards of accessibility;
- national urban design guidelines.

Conclusions resulting from a review of the capability of existing and emerging technology and resources to meet the needs of handicapped pedestrians with particular dysfunctions are grouped in the following sub-sections.

7.1 System Applications

The greatest opportunities for benefits at least cost are likely to accrue from pedestrian walkway and crosswalk system improvements close to the predominant residential areas of elderly and/or handicapped persons. The establishment of neighbourhood walkways for social and recreational uses surrounding isolated and clustered residences and institutional facilities so that major arterial streets are not crossed appears to have substantial benefits. Where pedestrian activities are concentrated, improvements in urban design are greatly needed, particularly with hazards created by the multiplicity of "street furniture" in the central business districts of cities.

7.2 Existing Technology

Significant experience exists in Canada with audible signals which are of particular benefit to the visually impaired and which may be helpful to some other categories of dysfunctions. At present, a great variety of "homemade" and commercial devices are installed which emit a wide range of sounds. More testing and eventual standardization of this technology is likely to be needed before the technology is more widely accepted.

It was encouraging to note that most communities are aware of the need for curb cuts for those persons using wheelchairs, however some of these curb cuts are not located in the preferred location. Also encouraging was a perceived willingness on the part of the traffic engineering community to make greater use of the capability of programmable traffic signals.

7.3 Development Needs

Technology used in other countries to enhance the usefulness of audible traffic signals for the visually impaired does not appear to have been tested or implemented yet in Canada. Technology designed to meet the needs of elderly and handicapped pedestrians with dysfunctions other than visual is not apparently being developed in Canada. Examples of technology that could be applied include:

- tactile locators for signal control buttons;
- easily activated control buttons;
- tactile surfaces on sidewalks for orientation and crosswalk boundaries;
- loop detectors for activating message systems;
- programs for traffic signals providing for pedestrian interruption frequencies of less than once per cycle;
- programmable signal control networks that provide for pedestrian-activated signals;
- locator audible signals to guide the visually impaired.

7.4 Institutional Needs

The institutional needs are substantial both for urban design guidelines and for motorist and pedestrian educational programs. Since the International Year of Disabled Persons, most jurisdictions are aware of building accessibility standards for disabled persons. Unfortunately, most of the building codes that have incorporated these accessibility standards stop at the building entrances. The extension of the effect of these codes to curbside (or at least the property lines) would be of substantial benefit to elderly and handicapped pedestrians.

Canadian traffic engineers are making valiant efforts, generally, to improve crosswalk safety conditions for the elderly and the handicapped. Further innovations are constrained by guidelines and standards developed a decade ago. Revised and expanded guidelines are required to stimulate the more intensive use of existing technology and implementation of new technology.

The Technical and Research Committee, Uniform Traffic Control Devices for Canada, is currently reviewing the need for inclusion of a section on audible signals under "Part B", which deals with traffic signals.(66) Some additional considerations are needed under the parts dealing with crosswalk lines.

It was generally agreed by the project team for this study that while there is a need for new educational programs for both motorists and pedestrians, broadly-based safety programs are not likely to be effective. The greatest benefits are likely to be obtained by providing training aids to the institutions that provide occupational therapists to train the elderly and handicapped to use the street systems. Programs that were aimed at developing a greater awareness of the needs of elderly and handicapped pedestrians by motorists would also be beneficial.

7.5 Federal Mandate

The federal government has an overall interest in the health, well-being and mobility of all Canadians. Health and Welfare Canada has a direct responsibility for "matters relating to the promotion and preservation of the health, social security and social welfare of Canadians."(67) The Ministry of State for Social Development has a responsibility to "formulate, develop, evaluate, and co-ordinate policies relating to programs and activities of the federal government that support Canadian Social Development and the well-being of Canadians."(68) The federal policy on the transportation of disabled persons is "to ensure the provision of safe, reasonable and equitable access to transportation modes under federal jurisdiction and to remove the barriers to travel, both physical and attitudinal, experienced by disabled persons."(69) This policy represents a commitment to the resolution of technological and managerial problems which limit the mobility of Canadians.

Within Transport Canada there are several directorates and programs that are concerned with the safety and well-being of pedestrians. These include: the Road Safety Directorate, the Surface Policy, Planning, and Urban Programs Directorate, the Transportation of the Handicapped program of the Co-ordination Branch, and the Transportation Development Centre of the Research and Development Directorate. The Advisory Committee on Transportation of the Handicapped advises the Minister of Transport on matters related to transportation systems of national interest.

Within the Canadian Surface Administration, the Road Safety Directorate has a responsibility for motor vehicle safety regulations which impact upon pedestrian safety. The Surface Policy, Planning, and Urban Programs Directorate has a "responsibility for developing federal policies and programs to assist in planning, developing, and financing urban transportation."(70) The Transportation of the Handicapped program is responsible for the co-ordination of departmental initiatives in the areas of "air transportation, VIA Rail, the Roadcruiser bus in Newfoundland, east coast ferries receiving federal subsidies, extraprovincial bus undertakings, and commuter rail."(71)

The Transportation Development Centre (TDC) has a "long-term systematic effort in research and development (R & D) underway to bring about innovations and improvements in the transportation system. Emphasis is placed on R & D to achieve a higher level of transportation safety and efficiency as well as to ensure accessibility for all Canadians, including the elderly and the disabled."(72) Since TDC acts as an in-house consultant and carries out its R & D program in collaboration with other components of Transport Canada, other federal government departments, provincial governments and the transportation industry, TDC has a far-ranging impact upon transportation systems and technology.

The federal government also has a direct interest in good architectural design. Public Works Canada is responsible for the management and direction of federal development projects and

construction as well as the development of standards and guidelines for the use of architects, engineers, and federal staff in the design and construction of buildings and in marine and transportation projects. The Canada Lands Company, responsible to Public Works Canada, is a corporate structure under which subsidiary Crown corporations have been established to manage and develop Crown-owned properties.

Other federal agencies, departments and Crown corporations are interested in the design of facilities to accommodate pedestrians. These include: the Airport and Construction Services branch of the Canadian Air Transportation Administration, the Canada Harbour Place Corporation, Canada Mortgage and Housing Corporation (CMHC), the National Research Council, and VIA Rail Canada Inc.

The Canadian Air Transportation Administration "provides standards and technical advice regarding the planning, design, costing, scheduling, construction, procurement, operation, and maintenance of airport-related facilities, mobile equipment and environments."(xx) This includes the requirements of the ground-side facilities at national airports.

The Canada Harbour Place Corporation "is a Crown corporation established in June 1982 to design and construct Canada Place in Vancouver. The result of a federal-provincial agreement, the project includes the Canadian Pavilion for Expo 86, which will subsequently be converted into Vancouver's Trade and Convention Centre, and a cruise ship facility, which is being built for Canada Ports Corporation (Ports Canada)."(73)

CMHC administers the National Housing Act and is authorized to insure mortgage loans made by approved lenders for new and existing homeowner housing, new and existing rental housing, and dwellings built by co-operative and non-profit associations. CMHC also undertakes studies on the planning and construction of housing and community services for senior citizens and the handicapped. Films, slides and publications are available to the public. Policy studies and technical reports on various aspects of housing and community development in Canada are available from the Canadian Housing Information Centre. The Canadian Housing Design Council (CHDC) is a national organization whose aim is to encourage the improvement of housing design in Canada, both in the house-building industry and in architecture, through the use of various educational programs and awards.

The National Research Council is responsible for "a comprehensive research program, carried out to meet Canada's needs for scientific information and knowledge in support of the construction industry. The Council provides technical support for the National Building Code for Canada, the National Fire Code for Canada, the Measures for Energy Conservation in New Buildings, Building Standards for the Handicapped, Residential Standards, and the Canadian Plumbing Code."(74)

VIA Rail Canada Inc. manages inter-city and long distance rail passenger service in Canada. VIA has a five-year program to modernize

the passenger rail services they operate including: new rolling stock, the upgrading of passenger station facilities, and improving the quality of rail transportation for passengers who have special needs.

VIA's definition of passengers who have special needs encompasses a wide spectrum of the population, "including: the very young and senior citizens, the obese, the arthritic, the non-ambulatory, pregnant women, passengers with speech, sight and hearing impairments, and any other passengers who suffer from a permanent or temporary disability."(75) VIA could be a potential implementor of some of the findings of this study because VIA works closely with special needs consumer groups and is, in many respects, a Canadian leader in the development of effective approaches to overcome access problems for pedestrians with special needs.

8. RECOMMENDATIONS

A functional specification for the improved safety of elderly and handicapped pedestrians (with benefits to all pedestrians) was developed in the course of this study. The specification, entitled "Improved Crosswalk Safety for Elderly and Handicapped Pedestrians - A Draft Functional Specification Including Urban Design Guidelines", is included in the Appendix section of this report. It is recommended that both the report and the draft functional specification be given the widest possible distribution among institutions, agencies and departments of government (at all levels) that may be able to stimulate further research and development into, and the implementation of, improved safety standards for elderly and handicapped pedestrians.

8.1 Stimulating Implementation

Since the more intensive use of the available technology to improve the safety of pedestrian crosswalks for the elderly and handicapped is dependent upon:

- user demand,
- education,
- standardization,
- local supply, and
- municipal specifications,

it is recommended that:

- The findings of this study be presented formally to the Technical and Research Committee, Uniform Traffic Control Devices for Canada.

- A copy of the final report be submitted to the national office of the Canadian National Institute for the Blind (CNIB) for review and comment.

- A copy of the report be sent to all national associations concerned with traffic safety and national advocate organizations for the handicapped.

- The summary report for this study be forwarded to all professional engineering associations and institutes in Canada and copies of the full report be sent upon request.

- The findings of this study be presented at the 1985 annual meetings of the Institute of Transportation Engineers and the Roads and Transportation Association of Canada.

- An invitational workshop session be included in the program for the Fourth International Conference on Mobility and Transport of Elderly and Handicapped Persons to be held in 1986; and representatives of the traffic signal manufacturers and suppliers,

municipal traffic engineers, occupational therapists and gerontologists be invited to develop a plan for stimulating further implementation of improved crosswalk system design.

8.2 Stimulating Development

Since further development of new crosswalk system technology is dependent upon a volume market, it is recommended that Transport Canada undertake the following:

- That the agencies of the federal government concerned with pedestrian safety be canvassed for interest in sponsoring a market evaluation for traffic signal technology.

- That the agencies of the federal government concerned with urban design for the elderly and the handicapped be canvassed for interest in sponsoring urban design guidelines and demonstration projects to test available and new crosswalk technology.

- That an assessment be made of the R & D resources available (including universities and research agencies) to carry out specific demonstration projects in improved crosswalk safety.

8.3 Recommended Demonstration Project

To support the stimulation of an effort to standardize the multiplicity of audible signals that are being used in Canada at present, the following is recommended:

- That one or more urban sites be selected to demonstrate state-of-the-art technology in audible traffic signals and related technology.

- That one of the sites be located in Vancouver in conjunction with Expo 86 activities, including the Fourth International Conference on Transport and Mobility for the Elderly and the Handicapped.

8.4 Recommended Educational Programs

It is recommended that Transport Canada directorates undertake to develop appropriate motorist and pedestrian safety education resources. Safety education programs for motorists should concentrate on making motorists more aware of the needs and limitations of handicapped pedestrians, particularly those limitations that are not readily visible. Pedestrian safety programs should draw on the experience of child safety programs and the training programs offered by occupational therapists.

8.4.1 Pedestrian Safety Programs

The following pedestrian safety program instructions are proposed as a guideline:

- Have eyesight checked and wear glasses when out on street if needed.
- Cross only at a crosswalk.
- Wear hearing aid when out on roads if needed.
- Look carefully for vehicles, including bicycles and motorcycles, when crossing.
- Cross where there is a median island or refuge if possible.
- If at all possible, avoid going out when there is ice or snow about.
- Carry or wear something conspicuous if going out in the dark or in poor light.
- Allow plenty of time for your journey.
- Do not cross near parked cars.
- Carry a white cane if eyesight is a problem.
- Cross via an overpass or underpass if available.
- Avoid rush hours and busy times.
- Avoid crossing more roads than really necessary.
- If possible, avoid going out when dark.
- If possible, avoid going out in poor light.

The "Green Cross" pedestrian code developed in Great Britain is recommended.(76) This includes the following instructions to pedestrians:

When crossing at a crosswalk:
- wait for traffic to stop.
- wait near the curb.
- look both ways.
- wait for near traffic to pass.
- cross within the crosswalk lines.
- cross steadily, don't rush.
- in one-way streets, look correct way.
- watch for vehicles overtaking those that have stopped at crossing.
- put foot on crossing to establish precedence.

When crossing between parked cars:
- go to outside edge of cars and do Green Cross Code there.
- check if parked car likely to reverse or move forward.
- choose as large a gap in traffic as you can.

Using the Green Cross Code:
- approach the crosswalk
- then stop
- look all around for traffic
- if traffic is coming, let it pass
- stand on the sidewalk near the curb
- when there is no traffic near
- first find a safe place to cross
- look all around
- walk straight across the road
- and listen for traffic
- keep looking and listening while you cross.

8.4.2 Motorist Safety Guidelines

Safety guidelines for motorists should include the following:

- Pedestrian needs are affected by their decreased physical capabilities or vision, perception, and reaction time.

- Pedestrians may not understand the purpose of the yellow or "DON'T WALK" clearance signal, and as a result may panic and begin running for fear of not making it safely across.

- The timing of traffic signals is of concern to older pedestrians as they may believe that traffic controls are designed for young, energetic persons with rapid walking gaits.

- The "right-turn-on-red" provision is now permitted in virtually every jurisdiction in the country. At some locations, this turning movement may be dangerous, especially for the older adult. Some vehicles do not completely stop prior to the turn. The driver's attention is often focused on approaching traffic and away from the pedestrian.

- Motorists making both left and right turns may experience "blind spots" created by the corner support posts of their vehicles. These become larger in inclement weather because windshield wipers do not clear the entire glass area. Such "blind spots" may become even more severe where side windows are fogged or dirty.

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APPENDIX

IMPROVED CROSSWALK SAFETY

FOR

ELDERLY AND HANDICAPPED PEDESTRIANS

A Draft Functional Specification Including

Urban Design Guidelines

PART 1 URBAN DESIGN GUIDELINES

The following urban design guidelines are intended to improve the safety of elderly and handicapped pedestrians in two ways:

by reducing the incidence of pedestrian/vehicle conflicts; and
by improving the design of the building to crosswalk link in the pedestrian mode.

1.1 Concentrated Residential Areas

In urban areas, where large numbers of the elderly and the handicapped are resident, recreational pedestrian routes should be established. Where possible, such pedestrian routes should avoid the crossing of major streets. Where major streets must be crossed, crosswalk design should be improved and audible traffic signals should be installed (see Part 2, Section 2.3 of this specification). Such designated pedestrian routes should include neighbourhood commercial, recreational, medical, and inspirational activity centres where possible.

1.2 Institutional Residences and Activity Centres

Developers of institutional facilities for the elderly and the handicapped should be required to provide accessible recreational pedestrian routes within the development or demonstrate that such routes are fully accessible to the institutional facility as a condition of obtaining a building permit. Where institutional facilities are isolated by major streets, fully accessible and secure pathways should be provided within or adjacent to the facility. This may require the acquisition of additional land or the obtaining of easements for pedestrian routes.

1.3 Low Density Residential Areas

Where the elderly and the handicapped are dispersed in low density residential areas, the community should consider the development and signing of the most accessible pedestrian routes. Such pedestrian routes should be developed in co-operation with neighbourhood representatives, taking into consideration such factors as traffic volumes, access to local activity centres and degree of maintenance required.

1.4 Crosswalk Access At Grade

The following guidelines are intended to improve the safety of access to pedestrian crosswalk facilities through improved sidewalk design. The guidelines can be used when improving existing conditions or as a condition of the approval of new construction. The guidelines apply equally to all pedestrian sidewalks whether in the CBD, in residential areas or within shopping centres.

The principal recommendations of visually-impaired user groups regarding walkways, crosswalks and street architecture were as follows:

(a) Use of Colour and Lighting - The use of colour to differentiate aspects of the environment is by far the most important aid for the visually impaired. Lighting is very important to more than two-thirds of the legally blind.

(b) Walkways and Wheelchair Ramps

- The camber of crowned or banked walkways and ramps should not exceed one in fifty, in cross section.
- In addition to textural changes on either side of a walkway, the edge of the path should also be of a colour in contrast to the path.
- The difference in level between the adjacent ground and the path should be less than 12 mm.
- The edges of the path should be level or slope slightly upward away from the path.
- A minimum footpath width of 1000 mm should be provided beyond the top of a wheelchair ramp.
- Wheelchair ramps should not be placed on a diagonal, but lead directly to the opposite side of the street (practice varies in Canada).

(c) Tactile Cues - Wherever walkways or wheelchair ramps join other walkways, ramps, driveways or parking areas, the transition should be indicated by a texture change of not less than 300 mm wide.

(d) Projections - Street furniture, stair balconies, branches and other obstacles should not protrude into the walkway area more than 125 mm (preferably not at all).

1.5 Grade-Separated Crosswalks

Where a level change is required due to high volumes of pedestrians and space restrictions, the access and egress to the grade-separated crosswalk must be fully accessible in accordance with current building codes. Guidelines for the design of crosswalk structures (which were beyond the scope of this investigation) have been developed by the Federal Highway Administration of the United States Department of Transportation. This manual, entitled "Guidelines for Making Pedestrian Crossing Structures Accessible", was published in August 1984. The guidelines, which were based on research work carried out at the Georgia Institute of Technology, were not intended as standards, but rather good practices for designers.

The principal recommendations with respect to access to and egress from grade-separated crosswalks were as follows:

(a) Access - The provision of dual access facilities (both steps and ramps) is desirable.

(b) Hazards - Protection from low projections is required. Railings and other barriers on open areas must have a low level bar that can be contacted by long canes used by the visually impaired.

(c) Signing - The use of tactile signing and large legend signs is

necessary. Signs must be located within pedestrians' normal field of vision.

(d) Landings - The provision of stopping or resting places is necessary for elderly and frail pedestrians.

(e) Handrails - The provision of non heat-conducting handrails is desirable for the elderly for cold weather conditions.

(f) Tactile Cues - The provision of detectable warning and guidance through tactile cues is needed for the visually impaired.

(g) Lighting - Adequate area lighting intensities are required as for interior building codes.

(h) Surfaces - Stable, slip-resistant surfaces are essential.

1.6 Designing for CBD Conditions

Where a major development or redevelopment is undertaken that includes the construction of curbs and sidewalks, the design of a safe pedestrian environment should be a condition of obtaining a building permit (see Section 1.4 above). Where the redevelopment includes pedestrian malls and other public facilities, the governing building accessibility codes should be applied to the external environment and the interface or "apron" between the external environment and the interior of buildings.

1.7 Designing for Commercial Activity Centres

The isolation of commercial activity centres by major arterial streets and large parking areas presents additional barriers and hazards to elderly and handicapped pedestrians. Most activity centres provide some reserved parking space close to the entrances, however little attention has been given to the customer arriving as a pedestrian. The following guidelines are proposed:

(a) Crosswalks - Grade-separated crosswalks should be continuous from the curb edges to the walkways serving the activity centre. Surface crosswalks should be provided with curb cuts through the path of travel to the walkways serving the activity centres.

(b) Painting - Crosswalk and walkway identification should be continuous from the property lines to the entrance walks serving the activity centre.

(c) Signing - Accessible pedestrian routes should be identified by signing with the wheelchair symbol.

(d) Benches - Benches and other street furniture should be fastened down so that they do not move when leaned against.

PART 2 SURFACE CROSSWALK SYSTEM DESIGN

Surface crosswalk design includes the physical design of the crosswalk, the design of the traffic signal systems if the intersection is signalized and any related information systems and signing.

2.1 Physical Design

The following guidelines represent improved crosswalk design. In most cases they go substantially beyond the Canadian standards contained in the Manual of Uniform Traffic Control Devices for Canada. They must therefore be considered as supplementary recommended practices.

The following recommended practices for good crosswalk design were derived from the Federal Highway Administration of the United States Department of Transportation implementation manual for "priority accessible networks" for elderly and handicapped pedestrians.

(a) Angled Crosswalks - Wherever possible, avoid oblique angle crosswalks. If, because of the layout of the streets, an oblique angled crosswalk is necessary, then at least one of the marking lines should be retained at 90 degrees to the curb, where this is practical. (This is not provided for in the Canadian standard.)

(b) Visual Obstructions - Avoid locating crosswalks where they are hidden from the view of drivers. Avoid locating street furniture, poles, mail boxes, telephone boxes, etc. on the sidewalk close to the crosswalk where they may hide pedestrians from view. Avoid locating crosswalks where entering pedestrians may be hidden from view by trees, planters and other planting materials.

(c) Parking Conflicts - Except where sidewalk extensions are provided, parking should not be permitted within 6 m of the nearest crosswalk. At signalized intersections, parking should not be permitted within 9 m of the nearest crosswalk at the intersection. On streets where legal parking is permitted at all times and traffic volumes are relatively low, pedestrian visibility can be improved by extending that part of the sidewalk that adjoins the crosswalk out to the edge of the parking lane. (This can also reduce pedestrian crossing time.)

(d) Crosswalk Dimensions - Crosswalk widths should be based on calculated pedestrian volumes. A width of 3.0 m is preferred. (The Canadian standard is a minimum of 2.5 m.)

Where there is likely to be a considerable amount of elderly and handicapped pedestrian traffic, and heavy volumes of vehicular traffic, the crosswalk length should be not greater than 23 m without providing a refuge island.

(e) Crosswalk Markings - For added visibility the area of the crosswalk may be marked with diagonal lines at a 45 degree angle or with transverse lines at a 90 degree angle to the line of the crosswalk. These lines should be 30 to 60 cm wide and spaced 30 to 60 cm apart.

When the diagonal or transverse lines are used, the longitudinal lines may be omitted. (This is not permitted in the Canadian standard.)

Crosswalk markings should present a slip-resistant surface for pedestrians. For crosswalk surfaces, avoid the use of brick paving or other materials in small units with many joints. The boundary lines or crosswalks should be made detectable to the visually handicapped.

(f) Orientation Cues - Special consideration for the needs of the visually impaired and the mobility techniques that they use must be considered at the beginning and end of crosswalks.

(g) High Volume Crosswalks - At crosswalks where there is substantial pedestrian traffic, platoon formation space should be provided, where this is possible.

(h) Barriers - Wherever possible, manholes, gratings and other access covers should not be located within crosswalks. If this cannot be avoided, then they should be made easily visible and slip resistant.

2.2 Traffic Signal Programming

Studies of ambulatory pedestrian crossing time requirements have shown that people walk at fairly uniform headways and speeds when they are travelling in large groups. Crossing speeds are slower for individual trips or where few pedestrians are crossing.

Crossing speeds are reduced for the elderly and handicapped when the signal status is uncertain. Crossing speeds are also affected by constraints such as sidewalk furniture, parked vehicles and congestions caused by pedestrians waiting for the signal for the alternate direction to change.

Standard practice is to design for an average crossing speed of 1.2 metres per second. The following alternatives should be considered:

(a) CBD Conditions - Restrict turning movements and set traffic controllers for a maximum walking speed of 0.9 metres per second on designated pedestrian routes.

(b) Auto-Dominant Conditions - Apply pedestrian-activated crossing technology and provide an opportunity for additional crossing time during off-peak periods.

(c) Pedestrian-Dominant Conditions - Apply pedestrian-activated crossing technology and provide an opportunity for additional crossing time through a design speed not exceeding 0.9 metre per second.

(d) Rural Conditions - Program traffic controllers for intermittent interruption of the cycle at slowest walking speeds.

2.3 Audible Traffic Signals

(a) Audible Range - To be effective the audible signal must accommodate noise levels at intersections ranging from 50 DB to 120 DB. It must

incorporate an audiometer controlled device that varies the sound level automatically depending upon the level of ambient noise (85 DB is a typical setting).

(b) Relatively Low-Cost Design - The audible signal installation must not add measurably to the total signalization costs of an intersection (preferably less than 5% of the cost of the signalization).

(c) Fail Safe Design - Audible signals should operate in the "GREEN" or "WALK" phase so that in case of failure the traffic signals revert to standard non-audible conditions. The signal must have a different, easily-distinguished sound for each direction. A variation between continuous and intermittent tones for the clearance interval is acceptable if the basic tone is not changed.

(d) Discrete, Non-Obtrusive Signal - Audible traffic signals must have a discrete sound that cannot be confused with other warning devices such as back-up beepers on buses, trucks and emergency vehicles. The sound must not be annoying to pedestrians or nearby residents. Provision must be made for adjustable upper and lower volume limits and a timer for turn-off during late night hours.

(e) Simple Installation - The audible signal unit should connect directly to the normal pedestrian signal head without the need for external wiring. It must not interfere in any way with the normal signal operation.

(f) Easily Maintained - the audible signal design must be compatible with current all-weather traffic signal technology. It should not increase the level of frequency of maintenance required.

(g) Adjustable for Direction - The audible signal must be capable of mechanical aiming and subsequent adjustment and locking on direction that the signal is being projected.

(h) Tactile Locator - The pedestrian-activated control button for the signal should be easily located. A textured surface strip locator placed at ninety (90) degress to the direction of travel and leading to the control button is desirable.

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Pedestrian Crosswalk Systems for the Elderly and the Handicapped

Summary Report

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PEDESTRIAN CROSSWALK SYSTEMS FOR THE ELDERLY AND THE HANDICAPPED

SUMMARY REPORT

by

W.G. ATKINSON

MANOP SERVICES LTD.

1007 Frederick Road
North Vancouver, B.C.
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December, 1984

0032

The contents of this report reflect the views of the Contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada. Where references are not quoted, the statements in the report reflect the experience of the project team.

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17 Abstract

This report summarizes the findings of a study that reviewed: the needs of the elderly and the handicapped, travelling as pedestrians; the urban crosswalk systems and traffic technology that have been developed to improve the safety of elderly and handicapped pedestrians; and,guidelines for further improvements in urban design. The main conclusion of the report is that most of the needs of elderly and handicapped pedestrians can be met by improving urban crosswalk systems for the benefit of all pedestrians.

The report includes a functional specification for improved safety in pedestrian crosswalk systems and recommendations for further development. The recommendations include:

- the stimulation of more intensive use of available technology;
- the development of new traffic signal technology;
- a demonstration of the state-of-the-art in audible traffic signals;
- the development of pedestrian and motorist safety education resources.

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17 Resume

Ce rapport résume les résultats de l'étude qui a passé en revue: les besoins des personnes âgées et des handicapés se déplaçant à pied; la question des passages piétonniers dans les villes et les techniques mises au point pour améliorer la sécurité de ces personnes lorsqu'elles les empruntent; les lignes directrices élaborées pour améliorer davantage ces techniques. Le rapport tire la conclusion principale qu'en améliorant de façon générale les passages pour piétons, on arrivera à satisfaire la plupart des besoins exprimés par la population âgée et celle des handicapés.

Le rapport propose un guide fonctionnel concernant l'amélioration de la sécurité dans les passages piétonniers et formule les recommandations suivantes:

- intensifier l'application des technologies existantes;
- mettre au point de nouvelles techniques de signalisation;
- faire la démonstration des signaux sonores relevant des techniques de pointe;
- prévoir un programme de formation et d'éducation en matière de sécurité routière pour les piétons et les automobilistes.

18 Mots-clés	19 Diffusion
Piétons, personnes âgées et handicapés, sécurité de la circulation, passages piétonniers, techniques de signalisation	Le Centre de développement des transports dispose d'un nombre limite d'exemplaires.

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1. INTRODUCTION

1.1 Background

The Transportation Development Centre (TDC) of Transport Canada has sponsored a series of investigations into the mobility needs of the handicapped. More than one-third of this segment of the population are elderly persons (aged 65 or more). Because of physical disabilities and/or the deterioration of major body functions due to illnesses and the aging process, such persons are faced with particular hazards when using the street system. Since many of the elderly and the handicapped have limited finances, they do a large part of their travelling the economical way - as pedestrians, increasing their exposure to vehicles and increasing risk of injury or death.

Pedestrian accidents involving the elderly may be associated with the progressive deterioration of major body functions. Decreasing visual and auditory sensitivity, the slowing down of decisions or of reaction time, mobility dysfunctions, and any disorientation may increase the risk of accidents. The characteristics of the aging process have been studied by gerontologists and information is available on loss of function. This information needs to be related to the design of crosswalk systems to improve pedestrian safety.

1.2 Objective of the Study

The objective of this study was to develop functional specifications for the improvement of pedestrian crosswalk systems related to the needs of elderly and handicapped persons. These functional specifications could then be considered by agencies such as the Council on Uniform Traffic Control Devices for Canada, for example, when revising the existing guidelines.

1.3 Report Content

The final report provides an overview of: the needs of the elderly and handicapped when travelling as pedestrians; the urban crosswalk systems and traffic technology that have been developed to improve the safety of elderly and handicapped pedestrians; and recommendations and guidelines for further improvements in urban design. The appendix section of the report contains functional specifications for improved safety in pedestrian crosswalk systems.

This report contains a summary of the content of the final report in a similar format. All aspects of the final report described above are included except for a detailed description of technology by country. In this report the type of signal systems and crosswalk technology to be found, both

nationally and internationally, are described in Chapter 5. The actual systems are described in more detail in the final report. Similarly, the summary report provides the results of an analysis of potential crosswalk system improvements in Chapter 6, whereas the final report (TP 5726E) includes more information on the analysis methods.

The functional specifications for improved safety in pedestrian crosswalk systems are repeated in the Appendix section of this report.

2. THE CLIENTELE AND THEIR NEEDS

For the purpose of this study, "THE ELDERLY" are arbitrarily defined as those persons "AGED 65 OR MORE". It is recognized that functional aging, whether biological, psychological, or social, can begin long before a person reaches the age of 65. The benefits from improvements in pedestrian crossings would thus accrue to a much larger clientele than just the elderly and the handicapped.

"THE HANDICAPPED" are usually defined as persons of any age who have a physical, mental, or medical condition, either permanent or temporary, that limits their mobility. This is a broad definition that has been used to define "THE DISABLED", encompassing the elderly, the obese, pregnant women and those persons with injuries.

2.1 The Ambulatory Elderly

This classification includes: those persons who may experience some loss of vision, hearing, touch sensitivity, or who are experiencing some psychomotor slowing or physical orientation problems, but who are not otherwise considered to be mobility handicapped.

2.2 The Ambulatory Handicapped

This classification includes: the visually impaired, the hearing impaired, those persons experiencing touch sensitivity problems and those with reading disabilities.

2.3 Semi-Ambulatory Handicapped

The semi-ambulatory handicapped include those with severe medical problems, such as heart disease, hemophilia, and cerebral palsy, for example; disabled persons using prosthetic devices that may limit their walking speed and dexterity;and those using walking aids, such as canes, crutches and walking frames (walkers).

2.4 Wheelchair Users

This classification includes all persons using wheelchairs for mobility. Many of these persons may also experience other disabilities.

2.5 Basic Needs of Clientele

The analysis and evaluation of optional pedestrian crossing systems and technology that could be of benefit to the elderly and handicapped required the development of basic user needs criteria. The consultants rejected a classification system for the handicapped based on medical illnesses and specific disabilities in favour of one using mobility and sensory needs as the criteria. The latter classification system allowed criteria to be

developed that could be used both to screen options and design new systems and technology. The following basic client needs were selected:

- ADEQUATE TIME to cross the roadway.
- BARRIER-FREE design.
- Proper ORIENTATION.
- Accurate INFORMATION.
- Ease of EDUCATION or training in usage (simplicity).

These needs criteria were used to evaluate optional systems and technology. Table 2-1 presents a summary of the user needs criteria developed and the segments of the elderly and handicapped (E & H) that apply to each.

Needs Criteria	E & H Segments Affected		
	Most Affected	Affected	Inconvenienced
ADEQUATE TIME	Semi-ambulatory: those with multiple dysfunctions	Persons using wheelchairs	The ambulatory elderly
BARRIER FREE	Visually impaired; persons using wheelchairs	Semi-ambulatory	The ambulatory elderly; persons with Cerebral Palsy
ORIENTATION	Visually impaired; Some segments of the elderly; the mentally retarded	Some segments of the elderly	The hearing impaired
INFORMATION	Visually impaired; the mentally retarded	Hearing impaired; reading impaired	The ambulatory elderly
EDUCATION	The ambulatory elderly	The ambulatory elderly	All segments

Table 2-1 Relative Influence of Various Needs Criteria on E & H Segments

3. THE PEDESTRIAN CROSSING SYSTEM

Pedestrian movements and vehicular traffic are highly related elements in the transportation system. The elderly and the handicapped, being a special kind of pedestrian, particularly when they occur in large numbers, will affect sidewalk and street capacities. This often leads to special crosswalk designs, grade-separated structures and tunnels inter-connecting major activity centres.

3.1 The Regulators

The pedestrian crossing system is part of the overall street and roadway systems which generally are regulated firstly by the provincial motor vehicle acts and secondly by the traffic bylaws of municipal governments. An understanding of current laws, traffic engineering principles and the characteristics of pedestrians will assist in the development of an effective and equitable solution to the transportation needs of the elderly and handicapped.

The provincial motor vehicle acts do not deal with elderly and handicapped pedestrians specifically. They are considered to be pedestrians in general. For all intents and purposes, elderly and handicapped pedestrians must observe the same rules as any other pedestrians.

Responsibility for the installation of crosswalks and traffic signal systems generally falls within the jurisdiction of the local government. City and district councils usually control and regulate traffic by bylaws under the power of the provincial municipal acts and the motor vehicle acts. Marked crosswalks other than those located at intersections are usually installed by resolutions of a municipal council.

In some cases, the installation of crosswalks is the responsibility of the province because some highways are classified as provincial highways. In other cases a special authority has been established.

3.2 The Need for Traffic Signals

The function of a traffic signal is to assign the right-of-way of vehicles and pedestrians. This is often necessary on major arterial streets where cross traffic would be seriously delayed by high volume traffic on the arterial. The proportion of "green time" given to each direction is based on the relative volumes of traffic in each direction, and the duration required for pedestrians to cross the roadway based on an average walking speed of 1.2 metres per second. Warrants for installing signals are published in the Manual of Uniform Traffic Control Devices for Canada, which include the review of traffic and pedestrian volumes (available gaps) and accident patterns.

3.3 Pedestrian Crossing Design

A pedestrian crosswalk is a traffic control device to guide pedestrians across the roadway. It is not intended as a protective device to save lives but an indication to warn motorists of a high pedestrian flow location. Crosswalks can be "marked" or "unmarked". Marked crosswalks are usually designated by white lines indicating a "stop line" for motorists. Crosswalk warning signs are often used. Unmarked crosswalks are at intersections and are defined by the extension of sidewalk boundaries. Early crosswalk designs often included safety islands and traffic barriers to provide refuge for pedestrians. These proved to increase vehicle accidents and are generally being eliminated in favour of wide medians, where possible.

3.4 Application Classifications Used in the Analysis

It was recognized early in this study that there is a wide range of traffic conditions impacting on the safety of pedestrians. These conditions range from high volumes of vehicles and pedestrians in the Central Business Districts of cities (CBD) to arterial and collector streets where vehicles outnumber pedestrians to residential neighbourhoods and shopping centres where pedestrians outnumber vehicles. Because special treatment of crosswalks and/or traffic signals for the benefit of the elderly and the handicapped is likely to vary with the local conditions, the following classifications were adopted:

- CBD CONDITIONS where both pedestrian and vehicle traffic volumes are high.
- AUTO DOMINANT where pedestrian volumes are low and vehicle capacity is critical.
- PEDESTRIAN DOMINANT conditions where vehicle capacity is not critical and pedestrian safety is paramount (i.e. near activity centres).
- RURAL CONDITIONS where volumes of pedestrians and vehicles are very low.

4. THE DESIGN OF SIGNALIZED PEDESTRIAN CROSSINGS

To accommodate elderly and handicapped pedestrians, the time required to cross the roadway may have to be increased. This could reduce intersection capacity in two ways: by the reduction of green time in the cycle, and by the delay of turning vehicles. It is therefore critical to review special crosswalk treatment for the elderly and handicapped to ensure that the transportation system as a whole would still be efficient. There should be a balance between the efficient and safe movements of all pedestrians, including the elderly and the handicapped, and the needs of the vehicular traffic.

4.1 Pedestrian Crossing Time

Traffic signals are generally set to provide a "WALK" clearance interval of sufficient time for a pedestrian to safely cross a roadway at a walking speed of 1.2 metres per second. Pedestrians entering the crosswalk when the "DON'T WALK" signal is displayed often do not have sufficient time to cross within the "GREEN" phase. Some communities have considered extending the timing to accommodate a walking speed of 0.9 metres per second when significant numbers of elderly or handicapped persons use a particular crosswalk.

4.2 Crosswalk Entrance Barriers and Hazards

There are two areas of concern to the visually impaired. The first includes hazards due to the placement of such items as sign poles, mail boxes, garbage containers and traffic signal controllers at or near the entrance to the crosswalk. The second area of concern is the construction of wheelchair ramps at the end of the sidewalk immediately prior to the pedestrian crosswalk.

4.3 Signal Control Buttons

There are a number of problems with current signal activation buttons. The handicapped pedestrian must be able to locate them, gain access to them and have sufficient strength to operate the control button. Some are large, spring-loaded controls and others are small buttons that need a strong finger to operate. Those with arthritis in the hands or arms may experience difficulty with these controls.

4.4 Crosswalk Design Constraints

It is more difficult to implement special traffic signals for the elderly and handicapped in central business districts because of the high volumes of pedestrians and traffic. The noise level is usually high in a downtown environment. Unless adequate space is provided in the crosswalk facilities, mobility for the handicapped is difficult. There are often physical constraints such as the availability of land for sidewalks.

Midblock crosswalks are considered unsafe because pedestrians do not usually follow them to cross the roadway. In rural and suburban areas,

midblock crosswalks may be acceptable with adequate signing and design. In CBD areas, where there are many commercial and regulatory signs with street architecture, landscaping and light standards, the effectiveness of pedestrian crosswalks, signs and signals is diminished.

4.5 Signal Status Information

Signal status information is of primary interest to the pedestrian. Standard placement of red, yellow and green signals is used to aid those with colour vision impairments. A great variety of audible signals are being used to aid in alerting visually-impaired pedestrians as to the signal status.

4.6 Parking and Vehicular Turning Movements

Vehicular traffic has a substantial impact on crosswalk access and safety, both by volume and motorist behaviour (and misbehaviour). Traffic authorities are often forced to limit pedestrian crosswalks to one side of an intersection because of the volume of vehicle turning movements. This is usually done where the capacity of the intersection would be severely reduced by introducing a pedestrian cycle or where pedestrian/vehicular conflicts have resulted in a history of accidents. The effect of this type of intersection may be a trade-off of time for improved safety of the elderly and the handicapped.

4.7 Pedestrian Orientation

Two sets of skills are needed if elderly and handicapped persons are to successfully negotiate the urban street environment. Firstly, they must know where things are in their environment. They must comprehend their own relationship to street architecture, building entrances, and at a larger scale, the layout of buildings and towns. This set of skills is called "orientation". Secondly, they must be able to travel safely from place to place. They must avoid hazards and stay on their path. This second set of skills, which is called "mobility", requires the minute-to-minute use of environmental clues.

4.8 Maintenance Requirements

Elderly and handicapped pedestrians are at risk where there is an accumulation of leaves, snow and ice, loose gravel and other debris in the crosswalk areas. Persons using walking aids, for example, may lose their balance when the walking aid strikes loose materials.

4.9 Illumination Requirements

There is a great deal of evidence that elderly people have diminished visual abilities under low levels of illumination such as nighttime or dusk. The amount of light reaching the retina of a 60 year old is approximately one-third that which reaches the eye of a 20 year old. As a result, roadways require good illumination, particularly at intersections.

5. REVIEW OF RELEVANT POLICIES, RESEARCH AND TECHNOLOGY

Most of the developments in improved safety for the elderly and handicapped, both nationally and internationally, have concentrated on the needs of the visually impaired. Only very recently (since 1980) have there been significant developments in overall system design. The currently applied systems and technology in Canada include:

- Audible traffic signals (limited applications).
- Grade-separated crosswalks.
- Experiments in signal timing.
- Development of programmable signals.

International applications include:

- Widespread use of audible signals with tactile locators.
- Use of tactile clues to locate control buttons, wheelchair ramps, crosswalk boundaries and sidewalk boundaries.
- Development of better architectural design guidelines.
- Development of crosswalk design standards.
- Investigation of closed circuit information systems for the hearing and visually impaired.
- Demonstrations of "talking" traffic signals.
- Development of more sophisticated systems for the preemption of traffic signals by pedestrians.

An analysis was made of current technology in view of the needs of the elderly and disabled as described in Chapter 2 of the final report. The deficiencies, primarily in Canadian approaches to design, are described in the following sections under headings developed as the "needs criteria" in Section 2.5 of Chapter 2.

5.1 Signal Programming (Adequate time)

In Calgary, Alberta, in certain cases, pedestrian signal clearance intervals are lengthened to match the time required for elderly or "encumbered" persons to cross the street. Normally the timing is established using a 1.2 m/second walking speed. When significant numbers of elderly or handicapped persons use the crossing, the timing is extended to accommodate walking speeds of about 0.9 m/second.

In Brandon, Manitoba, the introduction of new solid state traffic signal controllers has allowed the City Engineer to incorporate a four (4) second warning flash phase within the "DON'T WALK" period. This is to alert pedestrians that there may not be sufficient time to cross the street so they will wait for the next full cycle.

Typical current design standards for urban streets result in crossing widths ranging from about eighteen (18) metres for local streets and arterials to twenty-six (26) metres for six-lane urban highways. Crossing speeds of able-bodied pedestrians range from about 1.0 metre per second up to

about 1.4 metres per second for pedestrians crossing in large groups. Most traffic signals are set for an average crossing speed of about 1.2 metres per second. This speed translates into typical crossing times of from fifteen (15) to twenty-two (22) seconds. Studies of the needs of the elderly in Sweden showed that a walking speed of 0.9 metre per second would accommodate most needs and a speed of 0.6 metre per second would accommodate all but the very slowest. These speeds translate into average crossing times of about thirty (30) seconds.

5.2 Barrier-Free Design

It was apparent from the volume of literature available dealing with this aspect of urban design that the needs are well understood from the point of view of urban design. The deficiencies are that external design is not generally mandated in building codes, placement of obstacles occurs subsequent to the construction, and maintenance of walkways is often less than that desired by the users.

5.3 Orientation

The physical orientation needs of visually-impaired persons do not appear to be well understood. Current standards for crosswalk design do not adequately deal with intersections that are not constructed at right angles. Good examples exist, internationally, of the use of tactile clues to orient visually-impaired pedestrians. At present in Canada, the aids to orientation used in connection with traffic signals are mainly audible signals.

5.4 Information

Currently most information regarding the status of traffic signals is imparted visually. The red signal is always located at the topmost position or on the left side in the case of a horizontal signal mounting. Similarly, the "DON'T WALK" signal is mounted above the "WALK" signal. This allows some visually-impaired persons to know what the signal status is when the colour or pedestrian graphic symbol is not perceived. The use of shapes other than a circle for the signal heads is not currently being contemplated. The use of audible signals to supplement visual information is increasing slowly. Warrants do not exist for such installations in Canada. The use of other technology such as broadcast signals for those who are both hearing and visually impaired is not apparently being investigated for outdoor applications.

6. ANALYSIS OF POTENTIAL IMPROVEMENTS

The analysis of more intensive applications of existing technology and the implementation of new technology and resources is based on the premise that crosswalk system improvements currently being implemented by several municipal traffic jurisdictions will continue to gain acceptance, albeit not as quickly as some user advocate groups would like. The foregoing premise is taken as the "neutral path" condition from which the impacts of interventions in urban design, new crosswalk system technology, and the application of community resources are measured.

The analysis is based partly on observed common patterns of trip-making behavior, mobility factors and accident statistics for the elderly. Mobility factors include the following:

- mobility of the elderly is dependent upon an individual's judgement on their walking difficulty and sight problems rather than overall health;
- only the most severe difficulties result in a decrease of mobility within the neighbourhood;
- mobility outside the neighbourhood decreases with increasing sight and walking difficulties;
- a decrease of mobility outside of the immediate neighborhood results from a shortening of trip lengths rather than a lowering of the frequency of going out.

The pedestrian accident statistics for the elderly reveal that:

- a majority of the accidents occur within close proximity to the dwelling unit;
- a large percent of the accidents (43%) occur at intersections (21% where traffic signals exist);
- auto-dominant arterial streets present the most serious hazard.

Because the high rate of pedestrian traffic accidents among the elderly is an international phenomenon, several researchers have attempted to find common factors to explain the incidence. These investigations have concluded that the elderly have a disproportionate number of accidents based on exposure rates using such criteria as roads crossed, distance walked and hours spent in walking.

6.1 Evaluation of New Technology and Resources

The definition of "new technology" included all hardware and software that was not likely to be applied in the near future without some outside stimulus or intervention. The definition implies a departure from the neutral path conditions. This new technology is described in the following sub-sections:

(a) Signal Programs - Currently, the older mechanical traffic controllers are being replaced with solid state programmable controllers.

Some major cities such as Toronto have installed computer controlled traffic signal networks. Smaller versions of such networks are currently being considered for cities such as Vancouver, for example. Such systems may have the capability of accommodating the preemption of some "GREEN" time allocated to vehicles for the benefit of pedestrians on a cyclical basis. There is an opportunity to both extend signal cycles and vary signal programs if the necessary research and development is carried out.

(b) Tactile and Audible Locators - Tactile and audible locators have been tested internationally but have not yet been introduced to Canada. This technology has the potential to improve pedestrian orientation.

(c) Graphic Displays and Markings - The current design standards for traffic signals and crosswalk lines may be able to incorporate higher intensity markings and displays in addition to the minimum requirements.

(d) Pedestrian Information Systems - Pedestrian information systems for the communication impaired have been investigated in substantial depth by researchers at the Transportation Development Centre (TDC) of Transport Canada. Those systems that have the potential for use in connection with traffic signals include "loop systems" and talking signs.

6.2 Potential Benefits from Existing and New Technology

The potential benefits from the more intensive use of existing technology and the application of new technology are both social and economic. The major benefits are derived from improved safety for all pedestrians which has both social and economic consequences. The potential for reduced accidents was analyzed for the four application conditions applying the user needs criteria.

(a) CBD Conditions - The potential safety benefits from applications of new technology providing a barrier-free design are indicated to be the highest under CBD conditions because conflicts with street architecture may result in injuries over and above those created by pedestrian/vehicle conflicts. Improvements in crossing time and accurate information are indicated to be less effective due to congestion and smaller numbers of elderly and handicapped persons in the CBD areas.

(b) Auto-Dominant Conditions - These conditions, typical of major arterial streets acting as residential barriers, indicated the greatest potential benefits for improved safety through crosswalk design.

(c) Pedestrian-Dominant Conditions - The potential to improve on the safety of access to major pedestrian activity centres ranges from low for orientation to high for improvements in time and in applying educational safety programs. Improvements in barrier-free design and more accurate information through the use of audible signals indicated modest safety benefits.

(d) Rural Conditions - Modest safety benefits were indicated for proper orientation and accurate information because although the pedestrian volumes are low, these needs are the most troublesome.

6.3 Other Resources

In addition to applications of new technology, the more intensive use of resources would have a substantial impact on crosswalk system design and pedestrian safety. The potential additional resources identified by the consultant team in this study are described in the following sub-sections.

(a) Building Codes - Existing building codes could incorporate external design standards. Since most developers of major buildings are responsible for reconstructing the sidewalks and other pedestrian areas, a barrier-free design both externally and internally could be achieved.

(b) Design Standards - The existing standards for traffic signals and crosswalk lines could be supplemented by design standards based on the guidelines described in Section 5.3 of Chapter 5 of this report.

(c) Audible Signals - A greater use of audible signals could be stimulated in a number of ways. These could include inducements for local manufacture, resulting from the establishment of warrants and standards and a demonstration of the most effective technology.

(d) Education Program - The development of training aids and educational programs similar to those used in other traffic safety programs would likely have a significant impact on overall pedestrian safety.

Crosswalk Problem Statement	Clientele Affected	Degree of Impact (1)	Current Practices and Solutions	Impact of Current Design Practice	Potential for Improvement
Insufficient crossing time for pedestrians	(All segments) Ambulatory elderly Semi-ambulatory Wheelchair users	- 3 1 2	Install traffic signals. (Pedestrians cross only (on initial "GREEN" (signal. Safety programs.	Optimize vehicle movements. (Pedestrians - try to make (trips "off-peak". (Accidents.	Optimize all movements. (Program signal control (systems for more "GREEN" (pedestrian crossing time. (2) (More education.
Crosswalk access and/or entrance barriers and hazards	Ambulatory elderly Semi-ambulatory Wheelchair users Visually impaired	3 2 1 1	Lower curb heights. Repairs and reconstruction. (3) Install curb cuts & ramps. Remove obstacles.	Standards vary. (Standards vary. (Maintenance varies. Hazard to visually impaired. Cost to relocate curb cuts.	Establish design standards. Establish design standards. Anchor down furniture. Offset curb cuts. (4) Change surface textures. (4)
Barriers to pedestrian-activated signal controls	Semi-ambulatory Wheelchair users Visually impaired Reading impaired	2 2 1 3	Optimize control height. Optimize control height. No special treatment. No special treatment.	Force required varies. Access varies. May not locate control. May not understand symbols and instructions.	Bi-level controls better. Bi-level accessible controls. Tone pulse orientation. Tactiles. (5) Improve contrast and size of symbols and lettering.
Crosswalk design safety hazards	Ambulatory elderly Wheelchair users Visually impaired	3 2 1	Safety islands have been used. No special treatment. Limited use of texture.	Standards vary. Some delineation unsafe. (Unknown) (Unknown)	Establish spatial standards. Change to non-slip materials. Establish spatial standards. Orientation tone signals and textured spatial definition. (4)
Signal status information not received correctly by pedestrians	Ambulatory elderly Colour vision impaired Visually impaired Hearing impaired Reading impaired	2 2 1 3 2	No special treatment. Vertical signal patterns. Install audible signals. No special treatment. No special treatment.	High rate of accidents. (Unknown) (Unknown) (Unknown) (Unknown)	Reinforce with audible messages. Special lenses for "colour blind". "Talking signals". Tactiles. (5) Higher intensity lights. Messages to "hearing aid". Use language with symbols and verbal messages. Improve contrast.
High volume vehicle turning movements	(All segments) Hearing impaired	- 1	Limit pedestrian crossings to one side of intersection or use mid-block crosswalks	Unsafe pedestrian movements. Failure of motorists to yield right-of-way.	Education programs. Redesign intersection crosswalk. Grade separate crosswalks.
Insufficient surface crossing capacity for pedestrians	(All pedestrians)	-	Grade-separated crossings.	Difficult for the visually impaired and wheelchair users.	(Integrate with shopping (facilities, e.g. "Plus 15" (in Calgary. Improve access.
Pedestrians crossing outside of crosswalk	Handicapped children Ambulatory elderly	1 1	Safety education programs. Use driveway as a ramp.	Good user response. High rate of accidents.	(Install additional crosswalks. (safety education programs.
Pedestrian orientation problems	Psycho-motor slow Visually impaired Reading impaired	1 1 2	No special treatment. Some use of tactiles. (6) No special treatment.	High rate of accidents. (Unknown) (Unknown)	(Audible reinforcement; use (of male/female voices or ("bird calls" for orientation.
Abuse of curb parking by motorists	Mobility impaired Wheelchair users Visually impaired	2 1 1	Enforcement varies.	(Curb cuts and/or crosswalk (not accessible.	(Re-designed parking stalls, (education, and enforcement.

NOTES:

(1) Degree of Impact: "1" is "most affected"; "2" is "affected"; "3" is "inconvenienced".

(2) Communities installing computer-controlled traffic signal systems and programmable signal controllers may be able to provide an off-peak variance. The City of Calgary is experimenting with this technique, for example.

(3) Examples include: raising of catch basins, relocation of curb drains, and repairs to pavement and curbs.

(4) Visually impaired can use a "long cane" to detect abrupt changes in textures and in vertical elevations. Gradual changes are not easily detected.

(5) Signal control "tactiles" include vibration devices, heat devices and "Braille graphics".

(6) Crosswalk access "tactiles" include textured surfaces, "Braille tiles", and "threshold" strips.

Table 6-1 Impact of Crosswalk and Signal Design on the Elderly and Handicapped

7. CONCLUSIONS

Most of the needs of elderly and handicapped pedestrians can be met by improving the accessibility of urban crosswalk systems for the benefit of all pedestrians. The more specific needs of handicapped pedestrians with particular dysfunctions, such as the visually impaired for example, can be met by applying special technology developed for the purpose. Current deficiencies in crosswalk systems which impact upon the safety of all pedestrians can be overcome by better urban design. The key elements in overcoming both accessibility and safety deficiencies in urban crosswalk systems are the following:

- the national, provincial and local building codes;
- the Manual of Uniform Traffic Control Devices for Canada;
- national standards of accessibility;
- national urban design guidelines.

7.1 System Applications

The greatest opportunities for benefits at least cost are likely to accrue from pedestrian walkway and crosswalk system improvements close to the predominant residential areas of elderly and/or handicapped persons. The establishment of neighbourhood walkways for social and recreational uses surrounding isolated and clustered residences and institutional facilities so that major arterial streets are not crossed appears to have substantial benefits. Where pedestrian activities are concentrated, improvements in urban design are greatly needed, particularly with hazards created by the multiplicity of "street furniture" in the central business districts of cities.

7.2 Existing Technology

Significant experience exists in Canada with audible signals which are of particular benefit to the visually impaired and which may be helpful to some other categories of dysfunctions. At present, a great variety of "homemade" and commercial devices are installed which emit a wide range of sounds. More testing and eventual standardization of this technology is likely to be needed before the technology is more widely accepted.

7.3 Development Needs

Technology used in other countries to enhance the usefulness of audible traffic signals for the visually impaired does not appear to have been tested or implemented yet in Canada. Technology designed to meet the needs of elderly and handicapped pedestrians with dysfunctions other than visual is not apparently being developed in Canada. Examples of technology that could be applied include:

- tactile locators for signal control buttons;
- easily activated control buttons;
- tactile surfaces on sidewalks for orientation and crosswalk boundaries;

- loop detectors for activating message systems;
- programs for traffic signals providing for pedestrian interruption frequencies of less than once per cycle;
- programmable signal control networks that provide for pedestrian-activated signals;
- locator audible signals to guide the visually impaired.

7.4 Institutional Needs

The institutional needs are substantial both for urban design guidelines and for motorist and pedestrian educational programs. Unfortunately, most of the building codes that have incorporated accessibility standards stop at the building entrances. The extension of the effect of these codes to curbside would be of substantial benefit to elderly and handicapped pedestrians.

It was generally agreed by the project team for this study that while there is a need for new educational programs for both motorists and pedestrians, broadly-based safety programs are not likely to be effective. The greatest benefits are likely to be obtained by providing training aids to the institutions that provide occupational therapists to train the elderly and handicapped to use the street systems. Programs that were aimed at developing a greater awareness of the needs of elderly and handicapped pedestrians by motorists would also be beneficial.

7.5 Federal Mandate

The federal government has an overall interest in the health, well-being and mobility of all Canadians. The federal policy on the transportation of disabled persons is "to ensure the provision of safe, reasonable and equitable access to transportation modes under federal jurisdiction and to remove the barriers to travel, both physical and attitudinal, experienced by disabled persons." This policy represents a commitment to the resolution of technological and managerial problems which limit the mobility of Canadians.

Within Transport Canada there are several directorates and programs that are concerned with the safety and well-being of pedestrians. These include: the Road Safety Directorate, the Surface Policy, Planning, and Urban Programs Directorate, the Transportation of the Handicapped program of the Co-ordination Branch, and the Transportation Development Centre of the Research and Development Directorate. The Advisory Committee on Transportation of the Handicapped advises the Minister of Transport on matters related to transportation systems of national interest.

8. RECOMMENDATIONS

A functional specification for the improved safety of elderly and handicapped pedestrians (with benefits to all pedestrians) was developed in the course of this study. The specification entitled "Improved Crosswalk Safety for Elderly and Handicapped Pedestrians - A Draft functional Specification Including Urban Design Guidelines" is included in the Appendix section of this report. It is recommended that both the report and the draft functional specification be given the widest possible distribution among institutions, agencies and departments of government (at all levels) that may be able to stimulate further research and development into, and the implementation of, improved safety standards for elderly and handicapped pedestrians. This would include the presentation of the results of this study to:

- The Technical and Research Committee, Uniform Traffic Control Devices for Canada.
- National associations concerned with traffic safety and national advocate organizations for the handicapped, including the Canadian National Institute for the Blind.
- All professional engineering associations and institutes in Canada.
- The 1985 annual meetings of the Institute of Transportation Engineers and the Roads and Transportation Association of Canada.

8.1 Invitational Workshop

It is recommended that an invitational workshop session be included in the program for the Fourth International Conference on Mobility and Transport of Elderly and Handicapped Persons to be held in 1986; and that representatives of the traffic signal manufacturers and suppliers, municipal traffic engineers, occupational therapists and gerontologists be invited to develop a plan for stimulating further implementation of improved crosswalk system design.

8.2 Stimulating Development

To stimulate the development of new traffic signal and crosswalk technology in Canada, it is recommended that:

- The agencies of the federal government concerned with pedestrian safety be canvassed for interest in sponsoring a market evaluation for traffic signal technology.
- The agencies of the federal government concerned with urban design for the elderly and the handicapped be canvassed for interest in sponsoring urban design guidelines and demonstration projects to test available and new crosswalk technology.

- An assessment be made of the R & D resources available (including universities and research agencies) to carry out specific demonstration projects in improved crosswalk safety.

8.3 Recommended Demonstration Project

To support the stimulation of an effort to standardize the multiplicity of audible signals that are being used in Canada at present, it is also recommended that:

- One or more urban sites be selected to demonstrate state-of-the-art technology in audible traffic signals and related technology.

- One of the sites be located in Vancouver in conjunction with Expo 86 activities, including the Fourth Annual Conference on Transport and Mobility for the Elderly and the Handicapped.

8.4 Recommended Educational Programs

It is recommended that Transport Canada directorates undertake to develop appropriate motorist and pedestrian safety education resources. Safety education programs for motorists should concentrate on making motorists more aware of the needs and limitations of handicapped pedestrians, particularly those limitations that are not readily visible. Pedestrian safety programs should draw on the experience of child safety programs and the training programs offered by occupational therapists.

APPENDIX

IMPROVED CROSSWALK SAFETY FOR ELDERLY AND HANDICAPPED PEDESTRIANS

A Draft Functional Specification Including Urban Design Guidelines

PART 1 URBAN DESIGN GUIDELINES

The following urban design guidelines are intended to improve the safety of elderly and handicapped pedestrians in two ways:

by reducing the incidence of pedestrian/vehicle conflicts; and
by improving the design of the building to crosswalk link in the pedestrian mode.

1.1 Concentrated Residential Areas

In urban areas, where large numbers of the elderly and the handicapped are resident, recreational pedestrian routes should be established. Where possible, such pedestrian routes should avoid the crossing of major streets. Where major streets must be crossed, crosswalk design should be improved and audible traffic signals should be installed (see Part 2, Section 2.3 of this specification). Such designated pedestrian routes should include neighbourhood commercial, recreational, medical, and inspirational activity centres where possible.

1.2 Institutional Residences and Activity Centres

Developers of institutional facilities for the elderly and the handicapped should be required to provide accessible recreational pedestrian routes within the development or demonstrate that such routes are fully accessible to the institutional facility as a condition of obtaining a building permit. Where institutional facilities are isolated by major streets, fully accessible and secure pathways should be provided within or adjacent to the facility. This may require the acquisition of additional land or the obtaining of easements for pedestrian routes.

1.3 Low Density Residential Areas

Where the elderly and the handicapped are dispersed in low density residential areas, the community should consider the development and signing of the most accessible pedestrian routes. Such pedestrian routes should be developed in co-operation with neighbourhood representatives, taking into consideration such factors as traffic volumes, access to local activity centres and degree of maintenance required.

1.4 Crosswalk Access At Grade

The following guidelines are intended to improve the safety of access to pedestrian crosswalk facilities through improved sidewalk design. The guidelines can be used when improving existing conditions or as a condition of the approval of new construction. The guidelines apply equally to all pedestrian sidewalks whether in the CBD, in residential areas or within shopping centres.

The principal recommendations of visually-impaired user groups regarding walkways, crosswalks and street architecture were as follows:

(a) Use of Colour and Lighting - The use of colour to differentiate aspects of the environment is by far the most important aid for the visually impaired. Lighting is very important to more than two-thirds of the legally blind.

(b) Walkways and Wheelchair Ramps

- The camber of crowned or banked walkways and ramps should not exceed one in fifty, in cross section.
- In addition to textural changes on either side of a walkway, the edge of the path should also be of a colour in contrast to the path.
- The difference in level between the adjacent ground and the path should be less than 12 mm.
- The edges of the path should be level or slope slightly upward away from the path.
- A minimum footpath width of 1000 mm should be provided beyond the top of a wheelchair ramp.
- Wheelchair ramps should not be placed on a diagonal, but lead directly to the opposite side of the street (practice varies in Canada).

(c) Tactile Cues - Wherever walkways or wheelchair ramps join other walkways, ramps, driveways or parking areas, the transition should be indicated by a texture change of not less than 300 mm wide.

(d) Projections - Street furniture, stair balconies, branches and other obstacles should not protrude into the walkway area more than 125 mm (preferably not at all).

1.5 Grade-Separated Crosswalks

Where a level change is required due to high volumes of pedestrians and space restrictions, the access and egress to the grade-separated crosswalk must be fully accessible in accordance with current building codes. Guidelines for the design of crosswalk structures (which were beyond the scope of this investigation) have been developed by the Federal Highway Administration of the United States Department of Transportation. This manual, entitled "Guidelines for Making Pedestrian Crossing Structures Accessible", was published in August 1984. The guidelines, which were based on research work carried out at the Georgia Institute of Technology, were not intended as standards, but rather good practices for designers.

The principal recommendations with respect to access to and egress from grade-separated crosswalks were as follows:

(a) Access - The provision of dual access facilities (both steps and ramps) is desirable.

(b) Hazards - Protection from low projections is required. Railings and other barriers on open areas must have a low level bar that can be contacted by long canes used by the visually impaired.

(c) Signing - The use of tactile signing and large legend signs is

necessary. Signs must be located within pedestrians' normal field of vision.

(d) Landings - The provision of stopping or resting places is necessary for elderly and frail pedestrians.

(e) Handrails - The provision of non heat-conducting handrails is desirable for the elderly for cold weather conditions.

(f) Tactile Cues - The provision of detectable warning and guidance through tactile cues is needed for the visually impaired.

(g) Lighting - Adequate area lighting intensities are required as for interior building codes.

(h) Surfaces - Stable, slip-resistant surfaces are essential.

1.6 Designing for CBD Conditions

Where a major development or redevelopment is undertaken that includes the construction of curbs and sidewalks, the design of a safe pedestrian environment should be a condition of obtaining a building permit (see Section 1.4 above). Where the redevelopment includes pedestrian malls and other public facilities, the governing building accessibility codes should be applied to the external environment and the interface or "apron" between the external environment and the interior of buildings.

1.7 Designing for Commercial Activity Centres

The isolation of commercial activity centres by major arterial streets and large parking areas presents additional barriers and hazards to elderly and handicapped pedestrians. Most activity centres provide some reserved parking space close to the entrances, however little attention has been given to the customer arriving as a pedestrian. The following guidelines are proposed:

(a) Crosswalks - Grade-separated crosswalks should be continuous from the curb edges to the walkways serving the activity centre. Surface crosswalks should be provided with curb cuts through the path of travel to the walkways serving the activity centres.

(b) Painting - Crosswalk and walkway identification should be continuous from the property lines to the entrance walks serving the activity centre.

(c) Signing - Accessible pedestrian routes should be identified by signing with the wheelchair symbol.

(d) Benches - Benches and other street furniture should be fastened down so that they do not move when leaned against.

PART 2 SURFACE CROSSWALK SYSTEM DESIGN

Surface crosswalk design includes the physical design of the crosswalk, the design of the traffic signal systems if the intersection is signalized and any related information systems and signing.

2.1 Physical Design

The following guidelines represent improved crosswalk design. In most cases they go substantially beyond the Canadian standards contained in the Manual of Uniform Traffic Control Devices for Canada. They must therefore be considered as supplementary recommended practices.

The following recommended practices for good crosswalk design were derived from the Federal Highway Administration of the United States Department of Transportation implementation manual for "priority accessible networks" for elderly and handicapped pedestrians.

(a) Angled Crosswalks - Wherever possible, avoid oblique angle crosswalks. If, because of the layout of the streets, an oblique angled crosswalk is necessary, then at least one of the marking lines should be retained at 90 degrees to the curb, where this is practical. (This is not provided for in the Canadian standard.)

(b) Visual Obstructions - Avoid locating crosswalks where they are hidden from the view of drivers. Avoid locating street furniture, poles, mail boxes, telephone boxes, etc. on the sidewalk close to the crosswalk where they may hide pedestrians from view. Avoid locating crosswalks where entering pedestrians may be hidden from view by trees, planters and other planting materials.

(c) Parking Conflicts - Except where sidewalk extensions are provided, parking should not be permitted within 6 m of the nearest crosswalk. At signalized intersections, parking should not be permitted within 9 m of the nearest crosswalk at the intersection. On streets where legal parking is permitted at all times and traffic volumes are relatively low, pedestrian visibility can be improved by extending that part of the sidewalk that adjoins the crosswalk out to the edge of the parking lane. (This can also reduce pedestrian crossing time.)

(d) Crosswalk Dimensions - Crosswalk widths should be based on calculated pedestrian volumes. A width of 3.0 m is preferred. (The Canadian standard is a minimum of 2.5 m.)

Where there is likely to be a considerable amount of elderly and handicapped pedestrian traffic, and heavy volumes of vehicular traffic, the crosswalk length should be not greater than 23 m without providing a refuge island.

(e) Crosswalk Markings - For added visibility the area of the crosswalk may be marked with diagonal lines at a 45 degree angle or with transverse lines at a 90 degree angle to the line of the crosswalk. These lines should be 30 to 60 cm wide and spaced 30 to 60 cm apart.

When the diagonal or transverse lines are used, the longitudinal lines may be omitted. (This is not permitted in the Canadian standard.)

Crosswalk markings should present a slip-resistant surface for pedestrians. For crosswalk surfaces, avoid the use of brick paving or other materials in small units with many joints. The boundary lines or crosswalks should be made detectable to the visually handicapped.

(f) Orientation Cues - Special consideration for the needs of the visually impaired and the mobility techniques that they use must be considered at the beginning and end of crosswalks.

(g) High Volume Crosswalks - At crosswalks where there is substantial pedestrian traffic, platoon formation space should be provided, where this is possible.

(h) Barriers - Wherever possible, manholes, gratings and other access covers should not be located within crosswalks. If this cannot be avoided, then they should be made easily visible and slip resistant.

2.2 Traffic Signal Programming

Studies of ambulatory pedestrian crossing time requirements have shown that people walk at fairly uniform headways and speeds when they are travelling in large groups. Crossing speeds are slower for individual trips or where few pedestrians are crossing.

Crossing speeds are reduced for the elderly and handicapped when the signal status is uncertain. Crossing speeds are also affected by constraints such as sidewalk furniture, parked vehicles and congestions caused by pedestrians waiting for the signal for the alternate direction to change.

Standard practice is to design for an average crossing speed of 1.2 metres per second. The following alternatives should be considered:

(a) CBD Conditions - Restrict turning movements and set traffic controllers for a maximum walking speed of 0.9 metres per second on designated pedestrian routes.

(b) Auto-Dominant Conditions - Apply pedestrian-activated crossing technology and provide an opportunity for additional crossing time during off-peak periods.

(c) Pedestrian-Dominant Conditions - Apply pedestrian-activated crossing technology and provide an opportunity for additional crossing time through a design speed not exceeding 0.9 metre per second.

(d) Rural Conditions - Program traffic controllers for intermittent interruption of the cycle at slowest walking speeds.

2.3 Audible Traffic Signals

(a) Audible Range - To be effective the audible signal must accommodate noise levels at intersections ranging from 50 DB to 120 DB. It must

incorporate an audiometer controlled device that varies the sound level automatically depending upon the level of ambient noise (85 DB is a typical setting).

(b) Relatively Low-Cost Design - The audible signal installation must not add measurably to the total signalization costs of an intersection (preferably less than 5% of the cost of the signalization).

(c) Fail Safe Design - Audible signals should operate in the "GREEN" or "WALK" phase so that in case of failure the traffic signals revert to standard non-audible conditions. The signal must have a different, easily-distinguished sound for each direction. A variation between continuous and intermittent tones for the clearance interval is acceptable if the basic tone is not changed.

(d) Discrete, Non-Obtrusive Signal - Audible traffic signals must have a discrete sound that cannot be confused with other warning devices such as back-up beepers on buses, trucks and emergency vehicles. The sound must not be annoying to pedestrians or nearby residents. Provision must be made for adjustable upper and lower volume limits and a timer for turn-off during late night hours.

(e) Simple Installation - The audible signal unit should connect directly to the normal pedestrian signal head without the need for external wiring. It must not interfere in any way with the normal signal operation.

(f) Easily Maintained - the audible signal design must be compatible with current all-weather traffic signal technology. It should not increase the level of frequency of maintenance required.

(g) Adjustable for Direction - The audible signal must be capable of mechanical aiming and subsequent adjustment and locking on direction that the signal is being projected.

(h) Tactile Locator - The pedestrian-activated control button for the signal should be easily located. A textured surface strip locator placed at ninety (90) degress to the direction of travel and leading to the control button is desirable.